UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

MAINSTREAMING ADAPTATION TO CLIMATE CHANGE INTO DECISION MAKING IN THE WATER SECTOR: CONCEPTS AND CASE STUDIES FROM SOUTH AFRICA

by

SABINE INGRID STUART-HILL

Submitted in fulfilment of the academic
requirements for the degree of
PhD in the
School of Agricultural, Earth and
Environmental Sciences,
Discipline of Hydrology
University of KwaZulu-Natal
Pietermaritzburg

March 2015

ABSTRACT

Impacts of climate change are increasingly being felt by communities, especially those that are already vulnerable to other pressures of global change and who are at the mercy of poor governance. Adaptation to climate change has become an enabler through which to understand how impacts unfold and shape the well-being of communities and sectors. This calls for a strong emphasis on the design of actual management interventions and the mainstreaming thereof. The latter two factors have been identified as a gap in the past as well as in the current research arena of climate change adaptation.

The conceptual component of this thesis, *viz.* framing the preparation of decision-making for climate change adaptation and the design of management interventions that go with that, was supported by case study research in two divergent South African catchments. These case studies included participatory and action research in order to understand the setting as well as the current realities of decision-making in South Africa's water sector, the interplay of biophysical and socio-economic issues in regard to climate change impacts, as well as how this feeds into the design of adaptation management plans. In this regard, Integrated Water Resources Management and Adaptive Management have been identified as the canvas on which management activities need to evolve.

In a two-phase approach the research first aimed at understanding the policy and governance context and then moved into the domain of water resources management by looking closely at intervention design and implementation. Both phases targeted not only a better understanding of the South African environment of decision-making around adaptation, but also the derivation of key aspects for an overall mainstreaming approach of climate change adaptation into decision-making.

In the first phase two studies were undertaken in order to define the setting in which water sector decisions are currently made and to understand the realities of decision-making in the South African water sector. A SWOT analysis of South Africa's regulatory framework and policy landscape established that regulations do offer a unique and flexible format to proactively adapt to climate change. This includes tools to initiate review processes and to create catchment-tailored adaptation management plans that reflect specific needs, such as human resource management, monitoring and relevant participation. However, when

identifying the level of integration, of feedback and of adaptive capacity in the policy-management cycle, the research exposed that the implementation of this integrative and adaptive management approach was, overall, not well established and might in fact reinforce vulnerabilities and inequalities. The cycle weakens severely as the issues at hand become more demanding and complex. The results of these studies, combined with different concepts of mainstreaming and when reflecting this on a systemic, institutional and organisational level has shown that four characteristics are crucial when moving from design to decision-making, *viz.* flexibility, responsiveness, coordination and cooperation.

In the second phase the mainstreaming approach was developed further, focussing on the design of management interventions and again the mainstreaming thereof. The results derived identify organisational and individual levels to be more critical than the systemic level for mainstreaming. Certain skills are needed to successfully mainstream adaptation, these being connective communication, complexity management, and creative and visionary entrepreneurial skill. Armed with these findings, the research was moved 'back' into the case studies, aiming at understanding the interplay of biophysical and socio-economic impacts of climate change, and what the actual status of vulnerability was in the two case study catchments. This should then inform the design of adaptation interventions and the management thereof. It was concluded that simplistic assumptions on direct and indirect climate change impacts can be misleading and that each catchment and community would require different adaptation strategies and plans. Such diversification increases complexities around design, implementation and monitoring of adaptation strategies and related interventions. Catchment workshops underlined these outcomes as they showed that decision-makers did not appreciate the true extent of risks and threats which might occur under climate change. First, moments of surprise in understanding and contextualising impacts of climate change showed that assumptions based on expertise were dangerous and especially that the interlinkages of adaptation activities needed participatory reflection to enable informed decision-making. Secondly, the interplay of different governmental levels and leadership were found to be key to successful adaptation, but that these require corresponding budgets and substantial and recurring time commitments by all decision-makers and stakeholders involved. The assumption that a 'Space for Dialogue' could create innovative solutions and mainstream these into the home organisations of a catchment's 'champions' was only partially proven true for the South African cases. However, it was proven true that these

dialogues do offer the space for relevant and focussed knowledge exchange and for learning conversations, which can successfully develop integrated adaptation management plans.

For any future action research, a better understanding of the diverse windows of opportunity that revealed themselves in each step of the research journey has to be gained. Furthermore, one needs to better understand how leadership can ensure mainstreaming of climate change into day-to-day decision making. Only then will successful design and implementation of adaptation interventions be possible. Such leadership might then be able to learn from the various pockets of innovations that exist in South Africa and trigger a sustainable and continuous way of adapting to climate change in the water sector.

PREFACE

The conceptual and experimental work described in this thesis was carried out in the School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, from May 2008 to October 2013, under the supervision of Professor Roland E. Schulze and Professor Claudia Pahl-Wostl (University of Osnabrück, Germany).

These studies represent original work by the author and have not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text.

Furthermore, work and contributions made by the co-authors of each paper (Chapters 2 to 7) are described and acknowledged under Declaration 2 of this preface.

DECLARATION 1 - PLAGIARISM

I, Sabine Stuart-Hill, declare that

1. The research reported in this thesis, except where otherwise indicated, is my original research.

2. This thesis has not been submitted for any degree or examination at any other university.

3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

4. This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
   a. Their words have been re-written, but the general information attributed to them has been referenced
   b. Where their exact words have been used, then their writing has been placed in italics and inside quotation marks, and referenced.

5. This thesis does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the thesis and in the References sections.

Signed: ……
Sabine Ingrid Stuart-Hill

Signed: ……
Prof. Roland E. Schulze

DECLARATION 2 - PUBLICATIONS

DETAILS OF CONTRIBUTIONS TO PUBLICATIONS that form part and/or include research presented in this thesis (include publications in preparation, submitted, in press and published and give details of the contributions of each author to the experimental work and writing of each publication)

Publication 1 (*cf.* Chapter 2)

Stuart-Hill, S.I. and Schulze, R.E. 2010. Does South Africa's water law and policy allow for climate change adaptation? Climate and Development 2: 128–144.*Climate and Development* 2: 128–144; doi:10.3763/cdev.2010.0035.

Schulze: Access to current policy development and political initiatives

Publication 2 (*cf.* Chapter 3)

Stuart-Hill, S.I. and Schulze, R.E. (in preparation). A snapshot of South Africa's water resource management status. What does this indicate for overall water governance? *Journal of Environmental Management*.

Schulze: Assistance in choosing and contacting experts on national level

Publication 3 (*cf.* Chapter 4)

Stuart-Hill, S.I., Herrfahrdt-Pähle, E., Pahl-Wostl, C. (in preparation). Mainstreaming adaptation: Preparing decision-making in the water sector. *Environmental Science and Policy*.

Herrfahrdt-Pähle: Written contributions on the issue of "fit" and contributing to discussion on dealing with uncertainty

Pahl-Wostl: Assistance in discussion on social learning

Publication 4 (*cf.* Chapter 5)

Stuart-Hill, S.I. and Pahl-Wostl, C. (in preparation). Mainstreaming adaptation to climate change: Taking organisational issues into consideration for successful management interventions. *Ecology and Society. Special feature "The Governance of Adaptation"*.

Pahl-Wostl: Discussion and feedback on process-design

Publication 5 (*cf.* Chapter 6)

Stuart-Hill, S.I., Bulcock, L.M. and Schulze, R.E. (accepted for publication). Understanding links between water and societal vulnerability to identify climate change hotspots in South Africa. *Water SA*.

Bulcock: Compiling data and maps from Population Census 2001
Schulze: Selection of ACRU model runs

Publication 6 (*cf.* Chapter 7)

Stuart-Hill, S.I., Methner, N. and Lumsden, T. (in preparation). Exploring co-design of adaptation to climate change and prioritising interventions in South Africa. *Water Policy*.

Methner: Assistance in designing and observing champion workshops
Lumsden: Carrying out of the technical workshop in the Mgeni catchment

Signed: ……
Sabine Ingrid Stuart-Hill

LIST OF CONTENTS

LIST OF ABBREVIATIONS

AM – Adaptive Management
CMA – Catchment Management Agency
GMB – Group Model Building
IWRM – Integrated Water Resources Management
NWA – South African National Water Act of 1998
NWRS – National Water Resource Strategy of South Africa, 2004
RSA – Republic of South Africa
WSA – South African Water Services Act of 1997
WUA – Water User Association

GLOSSARY OF TERMS

ADAPTIVE CAPACITY: "Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies." (IPCC, 2007, 727)[1]

ADAPTATION: Adaptation is the conscious design and implementation of interventions in order to reduce existing as well as emerging vulnerability to impacts of climate change. Adaptation is part of integrated water resources management and is in itself an adaptive activity that needs to be repeated within relevant timeframes.

WATER COOPERATION: Cooperation and coordination of organisations and individuals beyond their day-to-day work, i.e. normally focused on colleagues and activities within one department on one governmental level. (UN, 2013)

WATER GOVERNANCE: "The notion of governance takes into account the different actors and networks that help formulate and implement water policy. Governance sets the rules under which management operates." (Pahl-Wostl *et al.*, 2012, 25)

[1] This term was the departure point with regard to the understanding of adaptive capacity at the commencement of the research process. Adjustments had to be made, based on the findings of this thesis and these are therefore discussed in the Conclusions in Chapter 8.

WATER MANAGEMENT: ”Management refers to activities of analyzing and monitoring, developing and implementing measures to keep the state of a water resource within desirable bounds.” (Pahl-Wostl *et al.*, 2012, 25)

VULNERABILITY: A state of an individual, community, sector or organisation based on its exposure, sensitivity and coping capacity to climate change impacts. Consequently, vulnerability is “determined by social entitlements” (Adger, 2001, 925) and the property of ‘adaptive capacity’ as a responsive element can mitigate impacts and therefore reduce vulnerability to a certain extent (Ionescu *et al.*, 2005).

REGULATION: A rule or legal document, including laws, bylaws, gazetted documents, and directives, designed by an executive branch of government or an authority delegated with such a task to rule or govern activities.

REGULATORY: “Serving or intended to regulate something” (Online Oxford Dictionary)

ACKNOWLEDGEMENTS

The author wishes to thank the following individuals and organisations for their assistance and contribution to this research:

Professor Claudia Pahl-Wostl and Professor Roland Schulze for their supervision, encouragement, guidance and patience throughout this project.

Professor Graham Jewitt and Professor Mark Laing for their mentorship and clear words of advice when needed, especially during the final phase of writing.

The School of Agricultural, Earth and Environmental Sciences and the Centre for Water Resources Research, respectively, at the University of KwaZulu-Natal for providing the financial, administrative and auxiliary resources used in this study.

My colleagues around the globe who have been available at any time for discussion and reflection, these including Dr. Elke Herrfahrdt-Pähle, Dr. Kathrin Knüppe, Nadine Methner, and Dr. Richard Meissner.

All those interviewees, experts and champions of South Africa's water sector who made themselves available to give this thesis the cutting edge and relevance I had aimed for right from the beginning.

The Water Research Commission (WRC) and also the National Research Foundation (NRF) for funding this research and providing opportunities to discuss the methodology, frameworks and results with influential researchers within and outside of South Africa.

Last, but by far not the least, my dear husband and my family, for their encouragement, support and understanding. It was not an easy journey, especially in the last year. And my dear friends in South Africa and overseas, who have been seriously neglected in these last two years. Thank you, sincerely. May normality prevail from now on.

1. INTRODUCTION

Climate change has been declared a major economic threat of the 21st century (IPCC, 2007b; United Nations, 2007; Bates *et al.,* 2008). Water, as the main resource of human life as well as of societal peace and economic activity is, therefore, increasingly moving into the focus of climate change impact studies as well as of debates around vulnerability and resilience of human well-being (Adger, 2001 and 2006; IPCC, 2007b; Bates *et al.*, 2008; Swatuk, 2008; Füssel, 2010; Moser, 2010; Cinner *et al.,* 2012). In the long term 'business as usual' will be expensive and not sustainable (IPCC, 2014). Hence, information and growing knowledge on the complex consequences of climate change on water resources have to be incorporated into decision-making processes on local, national, regional and global scales. In particular, it is contended that water managers on all governmental levels will have to mainstream such adaptation into their day-to-day work, with a focus on sustainable adaptation that avoids lock-in situations and inflexibility towards stresses and shocks.

The research domain of this thesis lies within the theme of water management[1], as decision-making is core to management and because mainstreaming of climate change adaptation can only be achieved when decision-making incorporates the impacts of climate change on a continuous basis. However, the manner in which management activities unfold is strongly linked to the overall governance[2] arrangement, which is rooted in historical developments, culture, norms and legislative issues (Finnemore and Sikkink, 1998; Ahmad, 2009; Inderberg and Eikeland, 2009; Woodhill, 2010; Schreiner, 2013; Ténière-Buchot, 2013). Hence, conceptual research and theory development is a starting point, but in order to understand the realities of decision-making, management and decision-processes these need to be investigated within local contexts (Cleaver, 1999 and 2007; Ison *et al.*, 2011) and in more depth with regard to the organisational and individual environments of knowledge creation[3] and intervention design (Jasanoff, 1996 and 2003). This is why this thesis is viewed as a hybrid of conceptual work, *viz.*

[1] According to Pahl-Wostl *et al.* (2012, 25): "Management refers to activities of analyzing and monitoring, developing and implementing measures to keep the state of a water resource within desirable bounds."
[2] According to Pahl-Wostl *et al.* (2012, 25): "A governance system […] encompasses structural features and transient processes at both rule making and operational levels. The notion of governance takes into account the different actors and networks that help formulate and implement water policy. Governance sets the rules under which management operates."
[3] The term "knowledge creation" is understood here as the knowledge derived from data and other information, including collaborative activities, before options are created or decision are taken on water orientated interventions.

framing the preparation of decision-making for climate change adaptation and the corresponding design of management interventions (*cf.* Chapters 4 and 5), and of case study research which includes participatory and action research. The latter aims at understanding the setting as well as the realities of decision-making in South Africa's water sector at the present point in time, as well as understanding the interplay of biophysical and socio-economic challenges in regard to climate change impacts; and finally, how all this feeds into the design of adaptation management plans (*cf.* Chapters 2, 3, 6 and 7). Furthermore, the thesis is split into two sections, with the first investigating the policy and governance context (*cf.* Chapters 2 to 4), which is based on legal frameworks and organisational operations, but is strongly influenced by the organisational and individual realities when decisions are made. The second section then moves from the framing of the preparation of decision-making to the design of actual management interventions, including vulnerability assessments as a starting point, and identifying corresponding responsibilities for implementation and monitoring (*cf.* Chapters 5 to 7).

In the sections which follow, *viz.* 1.1 to 1.4, an introduction of the different problem domains is given (i.e. adaptation to, and mainstreaming of, climate change, using South Africa as a case study), concluding with an identification of knowledge gaps and a critical discussion of key issues for adaptation design and mainstreaming this into day-to-day decision making and resulting interventions. Section 1.5 will then outline the overall methodology, research questions and hypothesis of the thesis. A detailed and in-depth overall literature review is not presented due to the nature of the thesis being written in an accumulative format as a series of papers, each of which contains a literature review of the specific theme under discussion. It needs to be noted that Chapter 2 was published in 2010 as part of a special issue of *Climate and Development.* Chapters 6 has been reviewed and accepted for publication (*Water SA*). Chapter 3 and 4 are in preparation for submission (respectively to *Journal of Environmental Management* and *Environmental Science and Policy*). Chapter 5 and 7 are in preparation for submission (respectively to *Ecology and Society* and *Water Policy*).

1.1 Adaptation in Water Resources Management

Increasingly the ability to respond to change is considered to be crucial to governments, society and the economic sector in light of projected enhancements of climate variability and the prospect of climate change. As research based on the IPCC's Fourth Assessment Report shows, global warming and consequent climate change is projected

to carry on for the next century even if emissions were to be stopped today (IPCC, 2007a). To a certain extent some argue that current water management has not been designed to be flexible in regard to accommodating change (e.g. Pahl-Wostl, 2007; Sherwill *et al.*, 2007; Roux *et al.*, 2009) and to taking up new knowledge. However, water resource management needs flexibility when considering new insights. In multi-stressor environments as they exist in developing and lesser developed countries such as South Africa, climate change is added as an overarching stressor that further impacts on all spheres of the living world and, therefore, has to be part of any decisions taken which may impact directly or indirectly on water resources. Consequently, adaptation to change has to focus on the way in which water resources are used and managed (Muller, 2007). This can only be achieved by building and continually increasing our adaptive capacity[4], which may also be enhanced through sustainable development (Adger, 2001). But, as Franks and Cleaver (2009, p. 210) argue, "reducing interventions to oversimplified one- off and highly localised solutions or replicating best practice is […] unlikely to contribute to long-term sustainability." Adaptation cannot be dealt with by a set of formal rules or legislative policies. Its very nature calls for complex and innovative interventions that are robust on several scales and levels at the same time. The knowledge and tools used, and individuals involved, need to relate and reflect these characteristics / abilities. What is needed is an "open system of arrangements […] rather than […] normative principles of capability, transparency and accountability." (Franks and Cleaver, 2009, p. 211)

The above calls for a sound understanding of the overall water related system (in this instance the hydrological cycle and its interdependencies with other spheres – physical and anthropogenic), for a constant uptake of new information into decision-making processes (Vogel and O'Brien, 2006) as well as for the flexibility to change and be responsive to change (Olsson *et al.*, 2006; Pollard and du Toit, 2011) when learning from respective outcomes. Furthermore, the approach of adaptation cannot be reduced to designing and implementing interventions by individuals only, but needs to be accompanied by an approach of constant knowledge creation, integrated assessment and joint decision-making (*cf.* Section 1.3). Here the three levels of capacity-building as

[4] According to IPCC (2007b, 22), "Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences." However, as the research conducted under this thesis shows, this definition is too narrow and implies limitations that may be overcome by successful mainstreaming (*cf.* Chapter 8)

identified in the framework of UNFCCC and discussed by Ogallo (2010) will have to be reflected upon:

(a) The systemic level, which includes economic and regulatory policies as well as the accountability frameworks in which institutions and individuals operate;
(b) The organisational level, which includes organisations and institutions, the latter including the respective organisations' missions, mandates, cultures, structures, competencies, and human and financial resources; and last, but not least,
(c) The individual who is operating and making decisions within this environment.

To date the Integrated Water Resources Management (IWRM) approach – when compared to water market liberalization or water demand management – considers water in a broader "hydrological and sustainable development context" and includes the reform of human systems (TEC GWP, 2004a; TEC GWP 2004b) in order to gain benefits for each water user, including the environment. Hence, IWRM provides a framework within which a range of choices for adaptation can be evaluated (Schulze, 2008) as it at the same time assists in making choices based on people within their specific environment and catchment respectively. Three key attributes of IWRM make it capable of meeting the challenges of climate change, *viz.* integration of sectors that impact on water resources, effective institutions and organisations to manage trade-offs (Muller, 2007; Sadoff and Muller, 2009) and its nature as an ongoing and, therefore, responsive process (Figure 1.1).

Figure 1.1 IWRM as an ongoing process to respond to changing situations and needs (TEC GWP, 2004b)

Furthermore, IWRM promotes participatory approaches to all its activities. As Cleaver (1999) argues, this is a challenging approach as participation by itself is not necessarily empowering, neither does it automatically optimise decisions towards good governance. This emphasises the three levels of reflection for the research to be done in this thesis as listed earlier on page 3. IWRM also gears our thinking and design more towards people and their interaction with water instead of protecting water as a natural resource (Jonker, 2007).

The responsive dimension of IWRM provides the opportunity to strongly incorporate adaptive management (AM) features and thereby increase adaptive capacity significantly. Adaptive management includes improving water management policies and practices in a systematic manner, achieved "by learning from the outcomes of [already] implemented management strategies" (Pahl-Wostl, 2008), as shown in Figure 1.2. Such learning processes can go as far as changing basic system structures (Pahl-Wostl, 2007). Additionally, open information management is a key element that must include uncertainty aspects (Pahl-Wostl, 2008) as to how information was gained and processed, why it was rated relevant and how it is presented. Yet, as highlighted by Engle *et al.* (2011), the combination of these two approaches might also lead to tension and trade-offs, for example between flexibility and legitimacy.

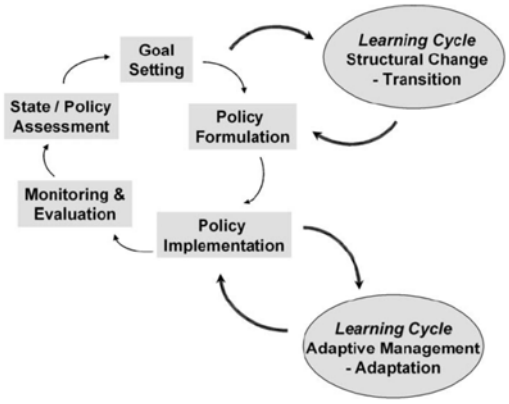


Figure 1.2 Adapting to change by learning in adaptive cycles (Pahl-Wostl, 2008)

However, beyond these more theoretical and abstract issues of management, the governance arrangements and the concepts of IWRM and AM, it is essential that policies and strategies lead to actual management interventions that are both implemented and adjusted. If that is not the case, then current as well as emerging

vulnerabilities under climate change will not lead to successful adaptation, i.e. change in livelihoods of people, and including a robust economy and resilience of ecosystems. Thus, water managers at all governmental levels will have to actually mainstream integrative knowledge on climate change impacts, will need to negotiate trade-offs and include adaptive management processes, all based on what has been learned, into their day-to-day work.

1.2 Mainstreaming Climate Change into Water Resources Management

Impacts of climate change may potentially be disastrous on a regional scale and its knock-on effects may, on the one hand, have serious implications for national economies. On the other hand, socio-economic activities generally display remarkable adaptive ability (Reid *et al.*, 2005). Detailed information on different levels of vulnerability is thus a key issue to be incorporated here. Vulnerability may be defined as the exposure to a threat in space and time, which implies that someone is vulnerable to something. This renders vulnerability a relative property to a potential event (Ionescu *et al.*, 2005), that includes the exposed unit's level of sensitivity to the event. The event can also be a constant stress that increases over time (e.g. enhanced climate variability). Vulnerability need not always to be a negative property as it may lead to beneficial development (Gallopín, 2006). In the context of climate change its impacts will affect sectors, groups and individuals in different ways. Hence, their respective vulnerabilities have to be differentiated. Such a differentiation depends on three key aspects, as Ionescu *et al.* (2005) describe, *viz.* effects of climate change have to be referred to a specific location, differences in groups and sectors define their relative importance, and the extent to which regions, groups and sectors are able to address effects of climate change need to be known.

Vulnerability has an internal and external dimension: The external dimension is the exposure to an impact as well as the relative sensitivity while the internal dimension is the capability to cope with the impact, which is equivalent to the degree of the system's adaptive capacity[5] (Gallopín, 2006). Consequently, vulnerability is "determined by social entitlements and differentiated by levels of equity, livelihood diversity, potential climate impacts and appropriate institutional forms" (Adger, 2001, p. 925) and the property of 'adaptive capacity' as a responsive element can mitigate impacts and

[5] "Capacity of response includes, for most authors, not only the resilience of the system (maintenance within a basin), but also coping with the impacts produced and taking advantage of opportunities." (Gallopín, 2006, p. 300)

therefore reduce vulnerability to a certain extent (Ionescu *et al.*, 2005). This presupposes information and knowledge on the matter in order to act. Moreover, we have to take into account uncertainties that will always surround the data and analytical tools of, say, climate change (Rogers *et al.*, 2000; Pahl-Wostl, 2007). Furthermore, vulnerability as well as the adaptive capacity of society is determined by institutional and economic parameters and these therefore either create an enabling environment or limit appropriate adaptation (Adger, 2001).

However, understanding or being aware of, vulnerabilities arising from climate change and its impacts does not automatically lead to adaptation activities by decision-makers (Grothmann and Patt, 2005; Brouwer *et al.*, 2013). In particular, water managers at all governmental levels will have to mainstream climate change into their decision-making by understanding the resultant impacts as well as then adapting to these in their day-to-day work. Here a broader approach than focussing on risks and direct, visible impacts on water resource management, such as floods and droughts, has to be taken. The approach also needs to be broader than taken by the concepts and insights of the environmental policy integration literature or the official development assistance, areas where mainstreaming was first highlighted and is basically understood as environmental policy integration (Klein *et al.*, 2005; Persson, 2008; Brouwer *et al.*, 2013). It rather needs to be a dynamic process with many uncertainties (Klein *et al.*, 2005; UNDP, 2009). It is not a means to an end, but rather needs to be partially iterative and on-going in a changing environment where information and knowledge are of importance in the management process. As Lyytimäki (2010) concludes, mainstreaming needs to look at an overarching climate agenda and not only at environmental implications.

All of the issues described above call for dynamic organisations that are well informed and offer leadership that can create effective strategies when adjusting to changing circumstances within the highly complex water sector (Muller, 2007; Snowden and Boone, 2007; Woodhill, 2010; Pahl-Wostl *et al.*, 2011). All of this lies beyond IWRM or AM on its own as a management approach. The uptake of new information must happen internally (i.e. across sectors and between government levels) as well as externally (e.g. by stakeholders either using, and/or impacting on, water directly and indirectly; or by appreciation of the latest research outcomes). These processes will only be efficient when awareness has been created within all partaking groups. Additionally, information itself, as well as knowledge constructed from it, has to flow “unobstructed” (Roux *et al.*, 2006, p. 1) between science and management, especially in times of change. Hence, relevant and applicable information has to be created taking differences

in “operational cultures and working philosophies into account” (Roux *et al.*, 2006, p. 2; Cleaver, 2007). Additionally, Lemos *et al.* (2010) have shown that technical knowledge is highly relevant and powerful for robust and effective intervention designs. Furthermore, knowledge is closely linked to adaptive capacity in the literature and thus represents a strong determinant of the level of adaptive capacity (Williams *et al.*, 2015). It thus seems valid to use scientific information as a starting point for knowledge production and intervention design.

In summary, integrating such information into decision-making around adaptation design calls for essential mechanisms such as dialogue and coordination (Rogers *et al.*, 2000; MacKay *et al.*, 2003; TEC GWP, 2004b; Vogel *et al.*, 2007), as well as cooperation, leadership and learning (Folke *et al.*, 2005; Olsson *et al.*, 2006; Termeer, 2009; Taylor *et al.*, 2011). This again points to three levels or dimensions that need to be taken into consideration in order to achieve mainstreaming successfully, *viz*. the systemic, organisational and individual levels, as mentioned already in Section 1.1. As Nilsson and Persson (2012, p. 61) word this challenge it is “likely [to] require comprehensive packages of governance response across both sub-systems and levels”.

1.3 South Africa as a Case Study

As alluded to earlier, the framework to be developed in this research will be based mainly on features of IWRM and AM. However, it will need to be placed into a more local context if it is to be proven applicable and successful in actual decision-making. Thus, governance, management and decision-processes need to be investigated in more depth within a specific case. The case study chosen is South Africa: a country representing a high risk natural environment, experiencing high levels of climate variability (Schulze, 2003) and societal inequalities (DEAT, 2006), but also exhibiting a very progressive legislative format in regard to water governance (MacKay *et al.*, 2003) and a seemingly robust economy. Generally in the South African context hydrological responses such as runoff amplify and intensify in particular any changes in rainfall characteristics (Schulze, 2008) and desiccation is likely to increase where rising temperatures in future are not matched by rising rainfall magnitudes (Muller, 2007; Sadoff and Muller, 2009). Additionally, land degradation is common in regions such as southern Africa which have a strong livestock orientated economy, especially among indigenous people and this is often exacerbated by poverty issues, including inadequate access to water, poor health and exposure to pollution (Seetal and Quibell, 2005). The overall deterioration of South Africa’s water resources is significant and on-going

(DEAT, 2006). By themselves these are already very challenging problems for South Africa already and are compounded by an on-going transformation process in society and the implementation of highly complex, albeit innovative, post-apartheid regulations (Schreiner, 2013).

In order to contextualise the issues of adaptation and mainstreaming on an even more local level, two climatically divergent test catchments were chosen: the Mgeni in the province of KwaZulu-Natal (along the eastern seaboard) and the Berg in the Western Cape (along the south-western seaboard). The Mgeni is in a summer rainfall area and the catchment contains a mix of land uses, including urban settlements, rural areas, subsistence and commercial farming as well as various open spaces and degraded areas. In comparison to the Berg catchment, poverty levels within the Mgeni are relatively high and educational levels are relatively low (StatsSA, 2003). Additionally, the Mgeni includes two major cities, Pietermaritzburg (the capital of KwaZulu-Natal) and Durban (South Africa's third largest city and Africa's largest port city). In contrast, the Berg catchment is situated in the winter rainfall region of the Western Cape Province along the west and south coasts of South Africa and supplies the City of Cape Town (South Africa's second largest city) with water. This catchment consists of a mixture of land uses just as the Mgeni. However, commercial farming is highly specialised and focuses on dryland wheat and mainly irrigated export orientated high value deciduous fruit.

At this juncture great concern must be expressed about any future economic development, as increasing disparities in water access and water availability result in increasing inequities and injustices. Projected impacts of climate change and the high likelihood of enhanced climate variability in future are now superimposed onto an unfinished and partially unpredictable governance system that exists in South Africa. Nevertheless, it seems that on a policy level many of the climate change issues are taken into consideration and awareness of climate change exists on all levels of government. Furthermore, pockets of innovative governance are in place (Biggs *et al.*, 2008; Colvin *et al.*, 2008; Pollard and du Toit, 2011; Never, 2012), but these seem not to up- or out-scale over time, and sometimes they do not even sustain themselves. Hence, South Africa presents itself as a challenging case, as it displays much of the flexibility and innovation that is needed in regard to a shift in water management and decision-making while at the same time it displays a diversity of governance and management weaknesses that have resulted in a continuously degrading resource base. The framework and concepts to be developed have to take this context into consideration in order to be relevant and implementable.

It needs to be noted here, that Rogers and Luton (2011) have successfully applied an adaptive management approach in the Inkomathi basin. However, with an existing catchment management agency (CMA) and a specific focus, *viz.* developing a catchment management strategy, Rogers and Luton had clear boundaries with regard to sub-catchments, organisation, and outcome when doing their research. The research undertaken in this thesis on hand does not have these clear boundaries. It rather looks at a space of dialogue or negotiation in which partakers develop their own, agreed upon agenda, and knowledge as well as values emerge that influences other decisions and initiatives in their day to day work. The latter are the dimension of mainstreaming.

1.4 Conclusion

As shown above, climate change adaptation and its mainstreaming into decision-making is a challenging task lying ahead of South Africa - as it is for many other countries -, especially in the water sector. Much has been written on diverse aspects of the above, but the level at which it matters is often avoided as it displays many complexities. This is the level of framing the preparation of decision-making for climate change adaptation and the design of management interventions that go with it. This calls for understanding the setting as well as appreciating the realities of decision-making in the water sector on the one hand, but also understanding better what the interplay of biophysical and socio-economic characteristics / vulnerabilities are in regard to climate change impacts and, additionally, how this feeds into the designs and negotiations of adaptation management plans. Thus, the research in this thesis is taking an approach of assuming that scientific information - or technical knowledge as it is called by Lemos *et al.* (2010) - on climate change impacts are valid and useful, but only if better understood in a catchment and more localised context. The aim taken is to develop interventions not to simply enable an individual to access enough water at an appropriate level of quality, but doing so without compromising other users and negotiating needs over time and space. This calls for additional information on needs and changes within catchments, which can only be added by users and other stakeholders. These might even be located outside the core water sector, i.e. municipalities, citizens etc. Therefore, the framing of the research is away from government as the sole decision-maker towards the idea of a more general network used to understand climate change impacts and develop interventions from there on.

Jasanoff (2010, p. 235) stresses the fact that “scientific facts arise out of detached observation whereas meaning emerges from embedded experience.” This means that climate change adaptation, in order to be both better integrated and mainstreamed into decision-making, needs to be contested, discussed and negotiated in order to ‘fit’ the dynamics of ecology, society and economy at a specific point in time for a specific place.

However, such discussions and dialogue require the transcending of scales and organisational boundaries in order to ensure the development and implementation of well-informed and sustainable adaptation interventions. This implies avoiding maladaptation, including the transfer of vulnerabilities, the amplification thereof and other negative impacts that may even be located beyond the water sector.

The content of the thesis reflects a process in itself, starting with the policy and governance context in Chapters 2 to 4, and moving into water resources management and intervention design as well as implementation in Chapters 5 to 7.

Four main conclusions are drawn from the knowledge gaps identified above, *viz.*

(a) A framework is needed that evaluates how climate change impacts should be understood and placed into the regional / local context, and furthermore, how this new knowledge should inform the design of management interventions.
(b) As adaptation has to be seen in a governance context (who makes a decision, when, and based on what knowledge?) the constitutional and legislature pre-conditions of a country have to be analysed.
(c) In order to know how actual decisions are taken as well as how new knowledge is processed on a day-to-day basis, one would have to analyse the functioning of the executive in a country, as well as the interaction and communication with civil society as a crucial first step.
(d) Finally, an understanding has to be gained, and tested, as to how actual mainstreaming of adaptation may take place in reality.

Here it needs to be noted that adaptation has to occur within the national as well as the catchment context and thus will often be a multi-level response as the impacts of climate change are so diverse (Adger, 2001). For South Africa its water history, based on a strong technical control paradigm and its impressive existing water related infrastructure, is a factor that has to be incorporated into adaptation strategies (Rogers *et al.*, 2000). Adaptation therefore has to consist of soft tools, such as those which

ecologists and social scientists use, as well as revisiting infrastructure, especially water storage options (Armstrong, 2009; Sadoff and Muller, 2009), in order to combine these in an effective and sustainable manner.

To suitably mainstream climate change issues into relevant policy and day-to-day decision-making processes for water managers and other related stakeholders, a space is needed where local and regional knowledge and needs meet policy guidance and where these are placed into the 'bigger picture' of water management. Therefore, negotiations within the catchment on water management in general, and adaptation in particular, need to take place in an appropriate 'space'. This space will have to combine characteristics such as dynamic institutions and organisations (Loorbach, 2010) with good leaders, detailed knowledge on vulnerabilities, relevant stakeholder participation, well established communication plans, well developed information and knowledge systems, flexibility and responsiveness etc. Champions from relevant government organisations as well as water user and stakeholder groups would need to be part of such a 'Space for Dialogue'.

1.5 Overall Thesis Outline and Methodology

The aim of this research was to establish a national framework for mainstreaming climate change into decision-making processes of water managers. In order to move beyond an academic exercise and create a relevant framework for South Africa, two experimental catchment processes were run. These processes were participatory and had the objective of creating tailored catchment adaptation management plans. An indispensable component of this was on-going assessments, evaluation, learning, feedbacks and adaptation. If a blueprint of these experimental catchment processes could be designed and such a process could be mainstreamed, the relevant organisations and institutions themselves could resolve the challenges of climate change adaptation sustainably through on-going learning cycles.

Two main aspects had to be incorporated in order to deal with the complex and messy space of decision-making: social learning and transdisciplinary research. The first aspect is key to understanding the impacts of climate change and the second to designing interventions and the prioritisation / implementation thereof. Social learning as shown, for example, by Pollard and du Toit (2011) and Rogers and Luton (2011) has to be context specific and needs to offer the individual flexible spaces for joint sense-making. As discussed by Ison *et al.* (2007, p. 500) it "provides a context for a dynamic

local decentralised process, and, in the case of large watersheds, for concerted parallel local processes." Furthermore, it is part of a post-normal science approach and offers all partakers alternative ways of sense-making and by that, developing alternative options. However, mainstreaming takes this even further by requesting learning organisations and reflexive management as well as governance. All this and the points discussed above calls for a research approach that moves beyond the boundaries of disciplines and making use of a certain type of methodology. Transdisciplinarity has thus been drawn upon in designing the overall methodology for this thesis. Based on the definition of Lang *et al.* (2012, p. 26) "Transdisciplinarity is a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge." In this thesis this relates to the qualitative research into legal frameworks and the performance of organisations (*cf.* Chapter 2 and 3), hydrological modelling in order to create a scientific point of departure, joint sense-making and co-producing knowledge (*cf.* Chapter 6 and 7), drawing on the political sciences in developing the framework (*cf.* Chapter 4 and 5). Finally, it complies with the requirements for transdisciplinary research as established by Lange *et al.* (2012) by engaging with the science-policy interface and practitioners in order to focus on societal relevant problems and being solution-orientated as well as creating a transferable practice. Here Swilling's (2014) discussion of the researcher's role of himself or herself needs to be reflected on: The capacities I was acting in related to, first, an expert researcher in developing scientific information as well as deploying the transdisciplinary research methodology, secondly, as a facilitator and, thirdly, as an observer. This apparent paradox needs to be recognised and has been attempted to be dealt with by avoiding as far as possible acting in several capacities at the same time. Furthermore, each capacity is reflected in separate research steps and has resulted in separate chapters.

The hypotheses of this research have been based on a number of assumptions:

(a) Vulnerability of the environment, economy and civil society could be significantly reduced by a proactive and adaptive integrated water resource management framework.
(b) Water managers are the nucleus for sustainable governance of water resources and of river catchments.
(c) Current water management is not able to adapt to the challenges of climate change.

(d) The starting point for a proactive and adaptive integrated water resources management framework is comprehensive information management, including inputs on knowledge and needs from researchers, forecasters, politicians and stakeholders.
(e) Capacity building and institutional development could make South African water managers more independent of external assistance, as well as more aware of uncertainties in fields of major concern.
(f) All of the above are fundamental to mainstreaming climate change into decision-making of water managers.

Hence, the hypotheses of this research were as follows, with the variable italicised and the hypothesis to be tested/assessed qualitatively being indicated in brackets:

(a) A pro-active management style needs to evaluate and adapt its *ways of decision-making on a relevant time scale* for the water user (therefore, develop a framework for introducing time periods of evaluation, and for creating space for transition and adaptation, which also frames the preparation of decision-making and overall mainstreaming of adaptive interventions based on all components of the research and specifically the action research in the catchments).
(b) Only through participatory processes is an *understanding of the present* and issues around vulnerabilities possible. Furthermore, barriers and drivers of change need to be understood and taken into consideration in order to make the framework real and implementable (hence, a SWOT analysis of the legislative format and expert interviews).
(c) Incorporating Spaces for Dialogue will induce *system innovations* for Integrative and Adaptive Water Management (therefore, design and hold champion workshops in the test catchments of the case study).

The process orientated manner of the framework suggested and the contextualisation needed in order to prove successful, resulted in a split of the research into two main phases: The first phase addressed the governance and policy context of water resources management and was broken down into three activities / chapters:

(a) Develop a conceptual framework on how to prepare decision-making in regard to climate change adaptation.
(b) Analyse the strengths, weaknesses, opportunities and threats of the legislative and policy format.
(c) Understand the current decision-making environment within the South Africa water sector.

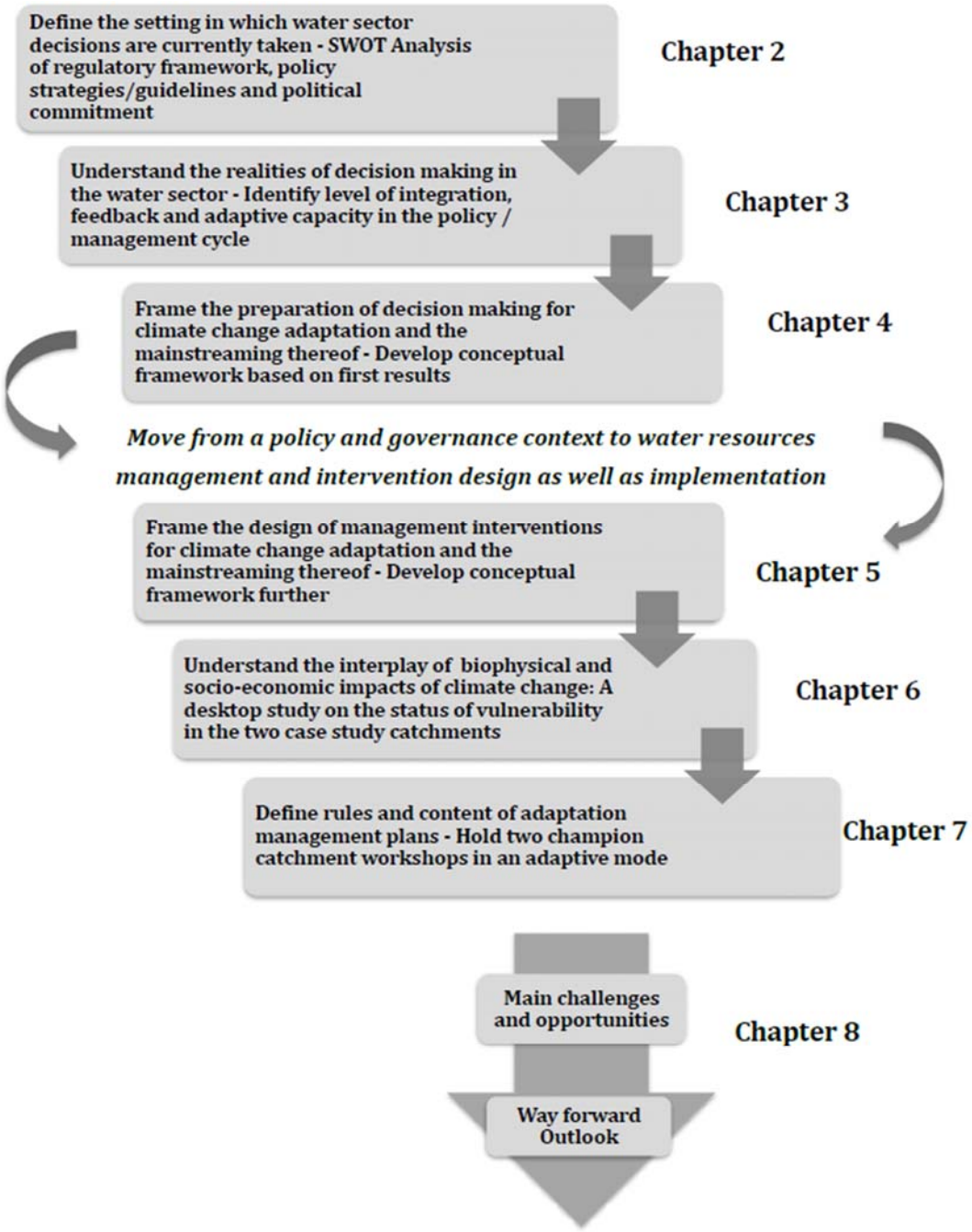
The second phase was to move into the intervention design and its implementation. It was also broken down into three activities / chapters:

(a) Develop a conceptual framework on how to design management interventions for climate change adaptation and its mainstreaming.
(b) Understand how the interplay between biophysical and socio-economic issues in a catchment influences the emergence of vulnerabilities in a future under climate change.
(c) Define the content of an adaptation management plan in an exemplary way in two divergent South African catchments.

The research conducted for this thesis aimed at mainstreaming adaptation to climate change into decision-making of water managers. Conceptually the focus was on the decision-making process of water managers and their way of designing management interventions for adaptation. Special attention was given to the catchment level as it offers itself as a primary space for dialogue in the South African governance and management arrangement. Expert interviews and catchment workshops tapped the indispensable local knowledge and needs, and made it possible to frame decision-making processes of different water users and managers at the same time.

This thesis has been written as a number of papers, either already published, or accepted for publication, or already submitted or in preparation for submission. Hence, some repetition of facts and issues will occur; there may also be certain contradictions as thoughts evolved and research results were gained. Cross-referencing between chapters and papers are also made. As an orientation for the reader and as a bridging page between the chapters and papers making up this thesis, Figure 1.3 should be referred to. This figure is repeated under the heading of each chapter, highlighting which stage of the process has been completed and concluding which key results have been gained. It will inform the reader what will be the next focus of research and discussion, and what remains to be investigated.

Figure 1.3 Overview and bridging page for this thesis



1.6 References

Adger, WN. 2001. Scales of governance and environmental justice for adaptation and mitigation of climate change. *Journal of International Development* 13:921-931.

Adger, WN. 2006. Vulnerability. *Global Environmental Change* 16:268-281.

Ahmad, IH. 2009. *Climate Policy Integration: Towards Operationalization*. DESA Working Paper No. 73. [Internet]. United Nations, New York, USA. Available from: http://www.un.org/esa/desa/papers [Accessed 23 January 2010]

Armstrong, AC. 2009. Viewpoint – further ideas towards a water ethic. *Water Alternatives* 2(1):138-147.

Bates, BC., Kundzewicz, ZW., Wu, S. and Palutikof, JP. (eds.) 2008. *Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change.* IPCC Secretariat, Geneva, Switzerland.

Biggs, HC., Breen, CM. and Palmer, CG. 2008. Engaging a window of opportunity: Synchronicity between a regional river conservation initiative and broader water law reform in South Africa. *Water Resources Development* 24(3):329–343.

Brouwer, S., Rayner, T. and Huitema, D. 2013. Mainstreaming climate policy: the case of climate adaptation and the implementation of EU water policy. *Environment and Planning C: Government and Policy* 31:134-153.

Cinner, JE., McClanahan, TR., Graham, NAJ., Daw, TM., Maina, J., Stead, SM., Wamukota, A., Brown, K. and Bodin, O. 2012. Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. *Global Environmental Change* 22:12–20.

Cleaver, F. 1999. Paradoxes of participation: questioning participatory approaches to development. *Journal of International Development* 11:597-612.

Cleaver, F. 2007. Understanding agency in collective action. *Journal of Human Development* 8(2):223-244.

Colvin, J., Ballim, F., Chimbuya, S., Everad, M., Goss, J., Klarenberg, G., Ndlovu, S., Ncala, D. and Weston, D. 2008. Building capacity for co-operative governance as a basis for integrated water resources managing in the Inkomati and Mvoti catchments, South Africa. *Water SA (IWRM Special Edition)* 34(6):681-689.

Department of Environmental Affairs and Tourism (DEAT) 2006. *South Africa Environment Outlook. A Report on the State of the Environment. Executive Summary and Key Findings.* Department of Environmental Affairs and Tourism, Pretoria, South Africa.

Engle, NL., Johns, OR., Lemos, MC. and Nelson, DR. 2011. Integrated and adaptive management of water resources: tensions, legacies, and the next best thing. *Ecology and Society* 16(1) Art. 19.

Finnemore, M. and Sikkink, K. 1998. International norm dynamics and political change. *International Organization* 52:887-917.

Folke, C., Hahn, T., Olsson, P. and Norberg, J. 2005. Adaptive governance of social-ecological systems. *Annual Review of Environmental Resources* 30:8.1–8.33.

Franks, T. and Cleaver, F. 2009. Analysing water governance: a tool for sustainability? *Engineering Sustainability* 162(ES4):207-2013.

Füssel, HM. 2010. How inequitable is the global distribution of responsibility, capability, and vulnerability to climate change: A comprehensive indicator-based assessment. *Global Environmental Change* 20:597–611.

Gallopín, GC. 2006. Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change* 16:293–303.

Grothmann, T. and Patt, A. 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change* 15:199–213.

Inderberg, TH. and Eikeland, PO. 2009. Limits to adaptation: analysing institutional constraints. In: eds. Adger, WN., Lorenzoni, I. and O'Brien, KL., *Adaptation to Climate Change: Thresholds, Values, Governance,* Ch. 27, 433-447. Cambridge University Press, Cambridge, UK..

Ionescu, CR., Klein, JT., Hinkel, J., Kavi Kumar, KS. and Klein, R. 2005. *Towards a Formal Framework of Vulnerability to Climate Change.* FAVAIA Working Paper 1 (NeWater Working Paper, 2). Potsdam Institute for Climate Impact Research, Potsdam, Germany.

IPCC 2007a. *Climate Change 2007: The Physical Science Basis. Summary for Policymakers. Working Group I Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report.* Geneva, Switzerland.

IPCC 2007b. *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability. Summary for Policymakers. Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report.* Geneva, Switzerland.

IPCC 20014. *Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, USA.

Ison, R., Röling, N. and Watson, D. 2007. Challenges to science and society in the sustainable management and use of water: investigating the role of social learning. *Environmental Science and Policy* 10:499-511.

Ison, R., Collins, K., Colvin, J., Jiggins, J., Roggero, PP., Seddaiu, G., Steyaert, P., Toderi, M., and Zanolla, C. 2011. Sustainable catchment managing in a climate changing world: new integrative modalities for connecting policy makers, scientists and other stakeholders. *Water Resources Management* 25:3977-3992.

Jasanoff, S. 1996. The dilemma of environmental democracy. *Issues in Science and Technology* 13(1):63-70.

Jasanoff, W. 2003. Technologies of humility: citizen participation in governing science. *Minerva* 41:223-244.

Jasanoff, S. 2010. A new climate for society. *Theory, Culture & Society* 27(2-3):233-253.

Jonker, L. 2007. Integrated water resources management: the theory-praxis-nexus, a South African perspective. *Physics and Chemistry of the Earth* 32:1257-1263.

Klein, RJT., Schipper, EL. and Dessai, S. 2005. Integrating mitigation and adaptation into climate and development policy: three research questions. *Environmental Science and Policy* 8:579-588.

Lemos, MC., Bell, AR., Engle, NL., Formiga-Johnsson, RM. and Nelson, DR. 2010. Technical knowledge and water resources management: a comparative study of river basin councils, Brazil. *Water Resources Research* 46 W06523.

Lang, DJ., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M. and Thomas, CJ. 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability Science* 7(Supplement 1):25-43.

Loorbach, D. 2010. Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance: An International Journal of Policy, Administration, and Institutions* 23 (1):161–183.

Lyytimäki, J. 2010. Mainstreaming climate policy: the role of media coverage in Finland. *Mitigation and Adaptation Strategies for Global Change* 16(6): 649–661.

MacKay, HM., Rogers, KH. and Roux, DJ. 2003. Implementing the South African water policy: Holding the vision while exploring an uncharted mountain. *Water SA* 29(4):353-358.

Moser, SC. 2010. Now more than ever: The need for more societally relevant research on vulnerability and adaptation to climate change. *Applied Geography* 30:464–474.

Muller, M. (lead author) 2007. *Climate Change Adaptation and Integrated Water Resource Management – An Initial Overview. Policy Brief 5.* Technical Committee (TEC), GWP, Stockholm, Sweden.

Never, B. 2012. Collective learning through climate knowledge systems: the case of South Africa. *Politikon: South African Journal of Political Studies* 39(2):231-256.

Nilsson, M. and Persson, A. 2012. Can Earth system interactions be governed? Governance functions for linking climate change mitigation with land use, freshwater and biodiversity protection. *Ecological Economics* 75:61-71.

Ogallo, L. 2010. The mainstreaming of climate change and variability information into planning and policy development for Africa. *Procedia Environmental Sciences* 1:405–410.

Olsson, P., Gunderson LH., Carpenter, SR., Ryan, P., Lebel, L., Folke, C. and Holling, CS. 2006. Shooting the rapids: navigating transitions to adaptive governance of social-ecological systems. *Ecology and Society* 11(1):art.18.

Pahl-Wostl, C. 2007. Transitions towards adaptive management of water facing climate and global change. *Water Resource Management* 21:49-62.

Pahl-Wostl, C. 2008. Requirements for Adaptive Water Management. In: eds. Pahl-Wostl, C., Kabat, P. and Möltgen, J. *Adaptive and Integrated Water Management. Coping with Complexity and Uncertainty,* Ch. 1, 1-22. Springer Verlag, Heidelberg, Germany.

Pahl-Wostl, C., Jeffrey, P., Isendahl, N. and Brugnach, M. 2011. Maturing the new water management paradigm: progressing from aspiration to practice. *Water Resources Management* 25(3):837-856.

Pahl-Wostl, C., Lebel, L., Knieper, C., and Nikitina, E. 2012. From applying panaceas to mastering complexity: Toward adaptive water governance in river basins. *Environmental Science and Policy* 23:24–34.

Persson, A. 2008. *Mainstreaming climate change adaptation into official development assistance: A case of international policy integration.* EPIGOV Papers No. 36. Stockholm Environment Institute, Sweden.

Pollard, S. and du Toit, D. 2011. Towards adaptive integrated water resources management in southern Africa: the role of self-organisation and multi-scale feedbacks for learning and responsiveness in the Letaba and Crocodile catchments. *Water Resources Management* 25:3971–3976.

Reid, P., Massey, R. and Vogel, C. 2005. Climate and Development: Experiences of Farmers in KwaZulu-Natal, South Africa. In: ed. Schulze, RE., *Climate Change and Water Resources in Southern Africa: Studies on Scenarios, Impacts,*

Vulnerabilities and Adaptation. Report No. 1430/1/05, Ch. 25, 395-414. Water Research Commission, Pretoria, South Africa.

Rogers, KH. And Luton, R. 2011. *Strategic adaptive management as a framework for implementing integrated water resources management in South Africa*. WRC Report No. KV 245/10. Water Research Commission, Pretoria, South Africa.

Rogers, K., Roux, D. and Biggs, H. 2000. Challenges for catchment management agencies: lessons from bureaucracies, business and resource management. *Water SA* 26(4):505-511.

Roux, DJ., Rogers, KH., Biggs, HC., Ashton, PJ. and Sergeant, A. 2006. Bridging the science-management divide: moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecology and Society* 11(1):art.4.

Roux, DJ., Murray K., van Wyk, E., and Hill, L. 2009. *Enabling effective learning in catchment management agencies: A Philosophy & Strategy.* Report No. K5/1689. Water Research Commission, Pretoria, South Africa.

Sadoff, CW. and Muller, M. 2009. Perspectives on Water and Climate Change Adaptation. Better Water Resources Management – Greater Resilience Today, More Effective Adaptation Tomorrow. [Internet] A Perspective Paper contributed by the Global Water Partnership through its Technical Committee. Available from: https:// www.gwpforum.org [Accessed: March 2009].

Sherwill, E., Arendse, L., Rogers, K., Sihlophe, N., van Wilgen, B., van Wyk, E. and Zeka, S. 2007. Stakeholder connectedness and participatory water resource management in South Africa. *Water SA* 33(4):505-512.

Schreiner, B. 2013. Viewpoint - Why has the South African national water act been so difficult to implement? *Water Alternatives* 6(2):239-245.

Schulze, RE. 2003. *The Thukela Dialogue. The Thukela Dialogue Managing Water related Issues on Climate Variability and Climate Change in South Africa. Report to 'International Dialogue on Water and Climate'*. ACRUcons Report 44. University of Natal, Pietermaritzburg, South Africa.

Schulze, RE. 2008. Integrated Water Resources Management as a Medium for Adapting to Climate Change. Conceptual, scaling, impacts modelling and adaptation issues within a southern African context. In: ed. Petermann, T., *Towards Climate Change Adaptation - Building Adaptive Capacity in Managing African Transboundary River Basins*, Ch. 2, 41–63. Zschortau, Germany.

Seetal, AR. and Quibell, G. 2005. Water Rights Reform in South Africa. In: eds. Bruns, B.R, Ringler, C. and Meinzen-Dick, R., *Water Rights Reform: Lessons for Institutional Design*, Ch. 6, 153–166. Washington D.C., USA.

Snowden, D.J., and Boone, M.E. 2007. A leader's framework for decision-making. *Harvard Business Review* November 2007:69-76.

Statistics South Africa 2003. National Population Census, 2001. Statistics South Africa, Pretoria, South Africa.

Swatuk, LA. 2008. A political economy of water in southern Africa. *Water Alternatives* 1(1):24-47.

Swilling, M. 2014. Rethinking the science-policy interface in South Africa: Experiments in knowledge co-production. *South African Journal of Science* 110(5/6):78-84.

Taylor, A., Cocklin, C., Brown, R., and Wilson-Evered, E. 2011. An investigation of champion-driven leadership processes. *The Leadership Quarterly* 22:412–433.

Technical Committee (TEC) GWP. 2004a. *Policy Brief: Unlocking the Door to Social Development and Economic Growth: How a More Integrated Approach to Water can Help*. GWP, Stockholm, Sweden.

Technical Committee (TEC) GWP. 2004b. *Catalizing Change: A Handbook for Developing Integrated Water Resources Management (IWRM) and Water Efficiency Strategies*. GWP, Stockholm, Sweden.

Ténière-Buchot, PF. 2013. Viewpoint – Happy like a clam in French Water. *Water Alternatives* 6(2):218-238.

Termeer, CJAM. 2009. Water professionals and public leadership. *Irrigation and Drainage* 58:S212–S216.

UNDP. 2009. *Adaptation definitions and levels*. Web-based: http://www.undp.org/climatechange/adapt/definitions.html#11.

United Nations (UN) 2007. *Africa and the Millennium Development Goals 2007 update.* DPI/2458. UN Department of Public Information, New York, USA.

Vogel, C. and O'Brien, K. 2006. Who can eat Information? Examining the effectiveness of seasonal climate forecasts and regional climate-risk management strategies. *Climate Research* 33:111–122.

Vogel, C., Moser, S., Kasperson, RE. and Dabelko, GD. 2007. Linking vulnerability, adaptation and resilience science to practice: pathways, players and partnerships. *Global Environmental Change* 17:349-364.

Williams, C., Fenton, A. and Huq, S. 2015. Knowledge and adaptive capacity. *Nature Climate Change* 5:82-83.

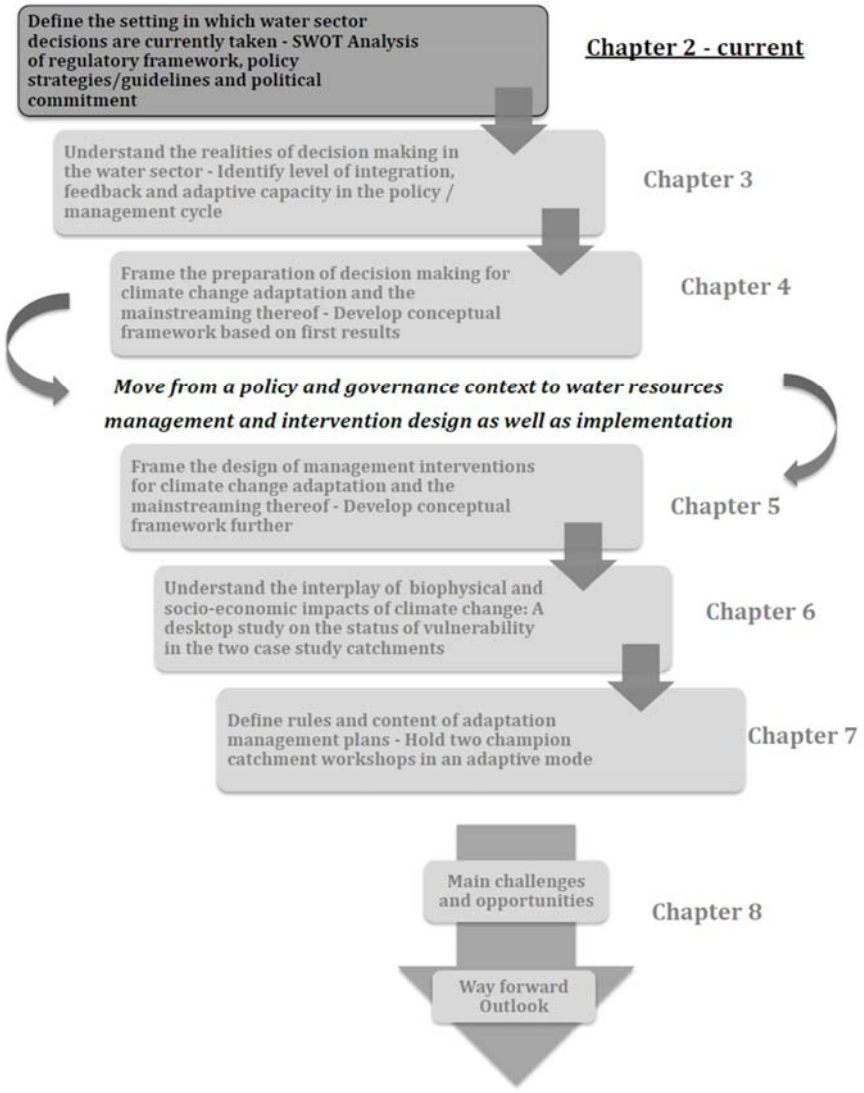
Woodhill, J., 2010. Capacities for institutional innovation: a complexity perspective. *IDS Bulletin* 41(3):47-59.

2. DOES SOUTH AFRICA'S WATER LAW AND POLICY ALLOW FOR CLIMATE CHANGE ADAPTATION?

S.I. Stuart-Hill, R.E. Schulze

School of Bioresources Engineering & Environmental Hydrology, University of KwaZulu-Natal, Private Bag X0, Scottsville 3209, South Africa

At the time of submission of this thesis (March 2015) this chapter had been published in *Climate and Development* (2010) 2:128–144; doi:10.3763/cdev.2010.0035.
According to the UKZN guidelines, the author's affiliation and reference list have been kept as per date of publication and rules of the journal. Only conventions used elsewhere in this thesis have been changed from the published version.



2.1 Abstract

The South African constitution enshrines the right to water for the well-being of its people. Recent Intergovernmental Panel on Climate Change and governmental reports show that this could be endangered by climate change. Recent high-resolution hydro-climatic model outputs give cause for further concern. Additionally, the South African Government is under pressure to implement progressive new water regulations; shift its overall water management approach; deal with skills shortages at all institutional levels; and cope with immense disparities and, hence, vulnerabilities within society. South Africa therefore faces huge water challenges in the coming years. This paper questions whether the country's regulatory frameworks and laws on water sufficiently support adaptation to climate change. Furthermore, questions are raised on incorporating climatic and other uncertainties into decision-making processes. It is concluded that South African water law and regulatory systems do offer sufficient flexibility and openness to cope with an adaptive and participatory management approach. This may lead to a progressive management era when current weaknesses and threats are addressed through self-reflection by all actors, as well as through building on cultural differences and incorporating the most recent research findings and other relevant information.

Key words: adaptation; climate change; South Africa; vulnerability; water management

2.2 Introduction

It is becoming clear that information and growing knowledge on the complex consequences of climate change on water resources have to be incorporated into decision-making processes. A 'business as usual' approach to water management in the long term will be expensive and not sustainable. In particular, water managers at all governmental levels will have to mainstream these issues into their day-to-day work, while at the same time incorporate other drivers of change and address diverse problems on different scales (Mertz *et al.*, 2009).

Section 2.5 of this paper briefly introduces the multi-stressor environment of post-apartheid South African society. Section 2.6 elaborates on adaptation in water resource management, with the aim of reducing vulnerable communities' exposure to climate change impacts. Sections 2.7 and 2.8 explore the South African regulatory format in regard to water resource management. Section 2.9 highlights the weaknesses and

strengths as well as the opportunities and threats of this format, and introduces the concept of a national framework tailored accordingly. Conclusions are drawn in Section 2.10.

Climate change is understood as global warming in combination with enhanced climate variability. Where appropriate, the authors will refer explicitly to one of the two; in any other cases, the term climate change will be used.

2.3 Methodology

Since 1994 South Africa has undergone a complex and intense period of transformation, which is likely to continue for many years. Combined with the effects of climate change, this places multidimensional pressures on water governance, which aims to reduce current vulnerabilities and overcome the inequalities of the apartheid legacy. The role of institutions and governance processes, both on a national and on a subnational level, is integral to this, and must be addressed (Adger, 2006). Furthermore, a broad but tailored scientific basis is needed on issues around vulnerability and adaptation to climate change, designed for decision-making at all governance levels (Vogel *et al.*, 2007; Moser, 2010). This paper asks what is needed, and what is offered, by existing South African water laws and regulations in order for the country to better adapt to projected impacts of climate change. Of course, any individuals taking adaptation decisions are embedded in many other 'push and pull' factors besides climate change in "their smaller, daily and larger, episodic decisions" (Moser, 2010, 468).

As objectives and methods are determined by the system studied, and hence its political and structural patterns within society (Adger, 2006), this paper adopts a two-step process: first, characteristics are defined for an adaptive and integrated water management approach focused on reducing vulnerability to the impacts of climate change and, secondly, laws and regulations underlying water management in South Africa are assessed; that is, how far laws are implemented and enforced, what political pressures are exerted and what preparedness for behavioural change exists. The concepts of vulnerability and integrated water resource management (IWRM) are used to frame the process towards adaptation actions.

2.4 A Specific Focus on Vulnerability and IWRM

It is clear that the diversity and inequalities of South Africa's society lead to a wide range of potential vulnerabilities to the projected impacts of climate change.

Vulnerability is exposure to a threat in space and time. This renders vulnerability a relative property to a potential event (Ionescu *et al.*, 2005), or a constant stress that increases over time (e.g. enhanced climate variability). Vulnerability may also lead to beneficial development (Gallopín, 2006). In the context of climate change, its impacts will affect sectors, groups and individuals in different ways. Hence their respective vulnerabilities have to be differentiated. Furthermore, thresholds have to be one of the key variables in the vulnerability approach as they define the boundaries of coping with stress or perturbations manifesting themselves "in specific places at specific times" (Adger, 2006, 276). This implies that a sound knowledge of the biophysical/ecological system as well as the socio-economic system that is under contemplation is needed.

A knowledge of vulnerabilities alone will not necessarily lead to adaptation. As elaborated upon by Moser (2010), vulnerability studies may identify intervention options as well as prioritizing adaptation actions, while adaptation itself has to look at how feasible and effective certain strategies can be and what interactions are indispensable. Only by understanding the pre-conditions and drivers creating vulnerabilities can the needs for a specific adaptation action be uncovered, understood and undertaken. Hence, pre-existing inequalities cannot be omitted as their effects could be exacerbated by the unequal distribution of vulnerability to climate change (Adger, 2006).

Consequently, vulnerability is "determined by social entitlements" (Adger, 2001, 925) and the attribute of 'adaptive capacity' as a responsive element can mitigate impacts and, therefore, reduce vulnerability to a certain extent (Ionescu *et al.*, 2005). Vulnerability thus has both internal and external dimensions, with the external dimension being the exposure to an impact and the internal dimension being the capability to cope with the impact, which is equivalent to the degree of the system's adaptive capacity[1] (Gallopín, 2006). Adaptation, therefore, needs a frame in which a potential action can unfold, hence increasing the likelihood of adaptation itself.

[1] "Capacity of response includes, for most authors, not only the resilience of the system (maintenance within a basin), but also coping with the impacts produced and taking advantage of opportunities" (Gallopín, 2006, 300).

As the sector under consideration here is water management, an approach that offers potential for adaptation action is needed. IWRM is such an approach. It considers water in a broader context of hydrological and sustainable development. Furthermore, it includes reform of human systems (TEC GWP, 2004a; b) to the benefit of water users as well as the environment.

IWRM's responsiveness (Figure 2.1) allows the incorporation of features of adaptive management, thereby increasing adaptive capacity. This includes improving water management policies and practices in a systematic manner, achieved "by learning from the outcomes of [already] implemented management strategies" (Pahl-Wostl, 2008, 1). This can go as far as changing basic system structures (Pahl-Wostl, 2007).

Such a dynamic approach is especially challenging for South Africa, where societal, economic and environmental concerns are embedded in an environment of continual change. The latter is due to vast inequalities in access to water and land, and with many new and, in part, highly innovative regulations leading to many new organizations and restructuring processes in the water sector. The still existing dual economy of rich and poor does not seem to be able to overcome the huge disparities that persist within society. IWRM and its inclusion in South Africa's legislation can be called "progressive policy thinking" that demands "progressive approaches to implementation" (Colvin *et al.*, 2008, 682). Colvin *et al.* (2008) therefore conclude that IWRM needs to be reshaped according to current spatial and temporal settings, putting learning, reflexivity and adaptation into the centre of implementation. Only then can IWRM emerge as an adaptive water management approach.

2.5 Climate Change Impacts and Vulnerabilities in South Africa

Southern Africa's hydro-climate is a high-risk natural environment. Overall it has a low mean annual precipitation and a low rainfall-to-runoff conversion rate, exacerbated by high inter-annual variability of rainfall, which in turn is amplified in responses of the hydrological system. Additionally, land use changes often increase flow variability,

Figure 2.1 IWRM as an ongoing process to respond to changing situations and needs (TEC GWP, 2004b)

particularly from degraded lands (Schulze, 2003), which are common in southern Africa owing to a livestock orientated livelihood among indigenous people and many small-scale farmers. In rural areas these patterns are often exacerbated by poverty (Seetal and Quibell, 2005). Water resources are therefore already stressed.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) describes expected impacts of climate change for the African continent. These include longer dry seasons and more uncertain rainfall, and reductions in yields from rain-fed agriculture by up to 50 % by 2020. Multiple stresses and low adaptive capacity place Africa as one of the most vulnerable continents to climate change (IPCC, 2007b), and specifically to enhanced climate variability.

2.5.1 Climate change scenarios for South Africa

General information such as that given above might guide the adaptation strategies, but it is not detailed enough to take specific actions at the national or regional level. Therefore, recent findings at the Quaternary Catchments[2] level over southern Africa are

[2] The South African Department of Water Affairs (now Department of Water and Sanitation) divided the RSA, Lesotho and Swaziland into 1 946 units representing the fourth level of subdivision for operational services.

illustrated below as an example for achieving more detailed and hence spatially relevant information. The findings use outputs from three general circulation models used in the fourth IPCC report (AR4; IPCC, 2007a), with daily values for precipitation and temperature empirically downscaled to local levels. These findings are based on the A2 scenario of greenhouse gas emissions, which seems the most probable to date[3] and in which it is assumed that 'efforts to reduce global emissions this century are relatively ineffective' (IPCC, 2007a; Lumsden *et al.*, 2009).

Figure 2.2 projects[4] that the east of the region is projected to become wetter while the west is projected to become drier. Increasing trends in mean annual rainfall, mainly over the eastern half of the region, are evident both for an intermediate future (2046–2065; Figure 2.2) and for a more distant future (2081–2100), with the latter displaying stronger changes (Lumsden *et al.*, 2009).

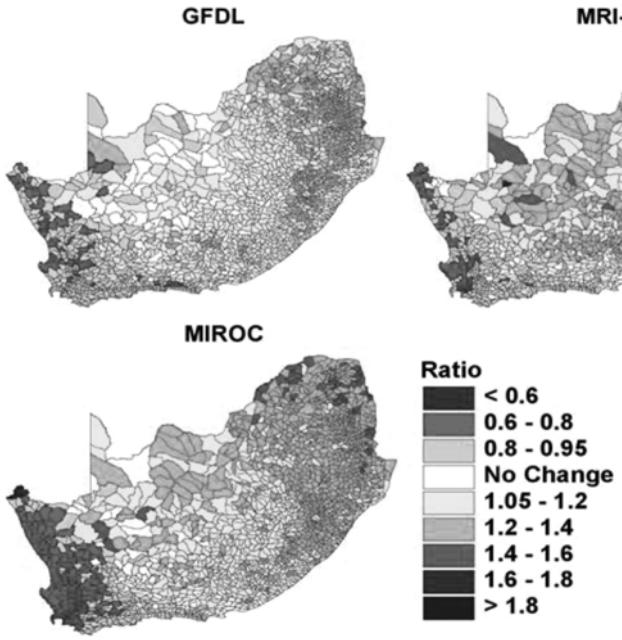


Figure 2.2 Projected changes from three AR4 General Circulation Models (GCMs) in mean annual precipitation between an intermediate future climate (2046–2065) and present climate (1981–2000)[5] (Lumsden *et al.*, 2009)

[3] Key Message 1 from the 2009 International Scientific Congress Climate Change in Copenhagen: 'Recent observations confirm that, given high rates of observed emissions, the worst-case IPCC scenario trajectories (or even worse) are being realised' (University of Copenhagen, 2009).

[4] The present climate (1981–2000) has been used as a baseline here. The ratio values indicate increases over time when >1 and decreases when, <1. Negligible changes are represented by 0.95–1.05.

[5] GFDL = GFDL:CM2.0 Geophysical Fluid Dynamics Laboratory, NOAA. MRI-CGCM = MRI:CGCM 2.3.2 Meteorological Research Institute, Japan Meteorological Agency. MIROC = NIES:MIROC 3_2-MED Model for Interdisciplinary Research on Climate.

Not only is a change in mean annual rainfall projected, but also in rainfall seasonality and variability. The total number of days per annum with more than 20 mm of rainfall, an amount that would be associated with stormflow generation and that would preclude mechanical field operations in agriculture, is projected to increase by 20 – 80% over the eastern part of the region, but with fewer such events expected in the west.

Generally in South Africa the hydrological cycle amplifies any changes in rainfall characteristics (Schulze, 2008), and consequently aridity is anticipated to increase where rising temperatures are not matched by rising rainfalls (Muller, 2007; Sadoff and Muller, 2009). Therefore, impacts of climate change over many areas in South Africa are expected to be severe. Furthermore, [for the GCMs used in this study] trends for the distant future are significantly more pronounced than those for the intermediate future (Lumsden *et al.*, 2009).

2.5.2 Regional vulnerabilities and the challenge of uncertainty

With the eastern part of the region projected to become wetter with heavier rainfall events (Lumsden *et al.*, 2009), this means that although more water may be available, there will be negative effects on sediment yields, siltation rates and aquatic ecosystems. Other problems might include increased flooding and reduced accessibility to fields and possible crop damage. The western part of the region is projected to become drier with an increase in flow variability (Lumsden *et al.*, 2009), possibly resulting in water being less available and more difficult to access, as well as less predictable stormflows (e.g. dam operations will have to be reconsidered, affecting reliability of supply).

In addition to the above, the 2006 State of the Environment report by the South African Department of Environmental Affairs and Tourism discusses changes due to severe mismanagement of water resources (DEAT, 2006). Thus many regions of South Africa may be close to unknown thresholds, the crossing of which may mean that sufficient water of an acceptable quality cannot be supplied. Hence, even moderate impacts of climate change could be critical and increase vulnerabilities, possibly on an exponential scale, or even lead to the collapse of vital ecosystem services.

Uncertainties surrounding the modelling of climate change impacts on water resources, as discussed by Lumsden *et al.* (2009), have been reduced significantly since the last IPCC assessment. Nevertheless, they still must be taken into account, as they increase

over time, and societal changes in this highly dynamic environment of change become difficult to predict. Thus water resource management needs constantly updated scientific and other information on impact assessments as well as on socio-economic developments. Only then can adaptation actions be prioritised accordingly and made relevant and sustainable in the long term, avoiding maladaptive practices and negative impacts on other sectors or neighbouring regions.

2.6 Characteristics of Water Management for Successful Adaptation

Adaptation has to focus on the way we not only use, but also manage, our water resources (Muller, 2007). The latter, especially, implies building and continuously increasing adaptive capacity, which may also be enhanced through sustainable development (Adger, 2001). However, to a certain extent current water management systems were not designed to be particularly flexible (Pahl-Wostl, 2007). If, therefore, adaptation is to succeed, water management must be flexible when dealing with new insights and multi-stressor issues. Climate change challenges our present decision-making processes (i.e. top-down, sector specific) and the information sources (e.g. statistics assuming climatic stationarity, or projections assumed correct) used to create knowledge. Most importantly, what is being adapted to must be identified, and here critical impacts of climate change and the resulting vulnerabilities to society, the economy and the environment are crucial issues.

Vulnerability is multi-dimensional. Its distinctiveness depends on spatial as well as temporal settings and hence vulnerability has to be carefully differentiated. Ionescu *et al.* (2005) describe this differentiation as depending on three key aspects that need to be known:

(1) effects of climate change at a specific location,
(2) the relative importance of different groups and sectors at that location and
(3) the extent to which regions, groups and sectors are able to address effects of climate change.

These characteristics are the first set of features for an adaptive and integrated approach in focusing on reducing vulnerabilities.

This paper views the potential for adaptation actions as an expression of adaptive capacity. The definition of *adaptive capacity* is based on that in the Fourth IPCC Assessment Report (IPCC, 2007b, 22): “Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate

potential damages, to take advantage of opportunities, or to cope with the consequences". This definition calls for:

(4) a comprehensive understanding of the overall hydrological system and its interactions with society and economy. As this is a highly dynamic relationship, it is a constantly moving and changing target.

(5) Hence, the constant uptake of new information into decision-making processes as well as

(6) the flexibility to respond to change become indispensable attributes of sound water management. In order to govern this process, characteristics such as cross-sectoral and integrative thinking are needed, as are effective and efficient institutions.

(7) Furthermore, open information management is a key element (Pahl-Wostl, 2008).

Characteristics 4 – 7 constitute the second set of features for an adaptive, integrated approach focused on reducing vulnerability.

It must be noted that water in South Africa is relatively scarce. Not only is it unevenly distributed geographically, but [uneven in regard to availability and access] also as a result of its pre-1990s social history (Weston and Weston, 2008). Consequently, decisions and activities surrounding adaptation on a local, regional and national level will 'reflect domestic political processes' (Sadoff and Muller, 2009), and will be strongly influenced by undoing the legacy of apartheid that has led to "extremely different access to water for productive purposes for different racial groups" (Schreiner *et al.*, 2009, 15). At the same time potential impacts of climate change on water resources still remain highly uncertain (Schulze, 2008), implying that adaptive capacity is vital.

Three key attributes of *IWRM* correspond to the attributes needed to build adaptive capacity and, hence, make it capable of meeting the challenges of climate change:

(8) integration of sectors that impact on water resources,

(9) effective institutions to manage trade-offs (Muller, 2007; Sadoff and Muller, 2009),

(10) and its nature as an ongoing and therefore responsive process.

Hence, IWRM provides a framework within which a range of choices for adaptation can be evaluated (Schulze, 2008), and is an iterative system that to a certain extent is a process of trial and error (TEC GWP, 2004b). Furthermore:

(11) it helps people to make choices through participation,

(12) within both their specific environment and their catchment.

Overall, IWRM promotes a strategic water allocation policy that aims at efficient investments across collaborating sectors and aims at gaining benefits from water resources (TEC GWP, 2004a). Characteristics 8 – 12 are, therefore, the third set of features for an adaptive and integrated approach focusing on reducing vulnerabilities.

Four main conclusions are drawn from the above and are discussed in the following sections. First, diversity and inequalities within South African society lead to vast disparities in the vulnerabilities and capacities of different communities to cope with change and stress. This calls for regional to local information on projected impacts of climate change as well as on individual needs and knowledge. Secondly, IWRM in itself is adaptive and hence is a water management approach with the ability to include adaptive management features and build the adaptive capacity needed to adapt to climate change. Thirdly, as adaptation has to be seen within a governance context (who makes decisions, when, and based on what knowledge?), the constitutional and legislative preconditions must be analysed. Finally, in order to know how real decisions are taken on a day-to-day basis, one would have to analyse the functioning of the executive, as well as its interactions with civil society.

The three sets of characteristics established in this section form the basis on which the regulatory framework of South Africa is evaluated.

2.7 The Cornerstones of the South African Legal Framework in Regard to the Water Sector

2.7.1 The constitution of South Africa as a point of departure

The basic rights enshrined in the South African Constitution that all have “a right to sufficient food and water” and “to an environment that is not harmful to their health or well-being” (RSA, 1996, 24(a)) have led to legislation that 25 litres of free water per day will be provided to every citizen (Free Basic Water, FBW). This does not imply a responsibility of government to supply this directly to each citizen, but to ensure that it is supplied (DWAF, 1996). This legislation has far reaching implications for South Africa’s water policies and regulations. Furthermore, the foundations have been laid for holistic, cutting edge and sustainable laws and regulations taking on environment, society and economy as equal partners in a sustainable manner (TEC GWP, 2004b).

This is reflected in a number of promising actions and documents passed respectively by Parliament and by Departments of State, including the National Water Act of 1998, the Water Services Act of 1997 and the National Water Resource Strategy of 2004, with the latter to be updated every five years (the next was due in 2009 [but only completed in 2013]). Regarding climate change documentation, this includes the National Climate Change Response Strategy (2003 [and updated 2011]), a Climate Change Research and Development Strategy (2009), a National Climate Change Response Policy (2009), as well as the development of climate change adaptation strategies in various key sectors such as water and agriculture (current at the time of writing), the ratification of the Kyoto Protocol (2002) and adoption of the Millennium Development Goals (2000).

However, as the capacity to cope and adapt is not high everywhere (Kabat and van Schaik, 2004), the basic human rights enshrined in the South African constitution are likely to be endangered by the impacts of climate change. But the development of adaptation strategies may offer opportunities for reducing vulnerability in many sectors other than water (e.g. agriculture, poverty and health) as well as other mitigating changes that might arise in future and that are as yet not fully understood (Schulze, 2003; DWAF, 2004; IPCC, 2007b).

2.7.2 The 1998 National Water Act of South Africa

In the period immediately following a change of government in 1994, the South African water law was rewritten (RSA, 1998). The main aim was to comply with paradigm shifts in the water sector, and to undo inequalities that affected certain ethnic groups (Seetal and Quibell, 2005), these being mainly the black population, but also to a significant extent coloureds and Indians. Furthermore, access to water being a constitutional right for all South Africans, the law had to focus, *inter alia*, on the well-being of specifically the formerly disadvantaged and poor, while simultaneously considering development and the effects on important sectors of the economy still dominated by groups of white descent.

The National Water Act (NWA) clearly declares “the need for the integrated management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level so as to enable everyone to participate” (RSA, 1998, Preamble). Consequently, IWRM is a guiding principle in the Act and leads to the three pillars of sustainability: society, the environment and the

economy. Participatory processes at all levels will help to balance the needs and constraints of these pillars, leading to equitable and sustainable development.

This has lead to the definition of the 'Reserve', split into the basic human needs reserve which "provides for the essential needs of individuals served by the water resource in question and includes water for drinking, for food preparation and for personal hygiene" (RSA, 1998, Chapter 2, Part 3), and the ecological reserve, which "relates to the water required to protect the aquatic ecosystems of the water resource" (RSA, 1998, Chapter 2, Part 3). The Reserve might vary and has to be seen in the context of local water quantity as well as its quality (RSA, 1998).

Furthermore, effects of land use have been incorporated as these can demonstrate strong feedbacks within the water cycle. Hence the concept of 'stream flow reduction activities' (SFRAs), implying that certain land uses have to obtain a licence if they are considered to reduce water availability to a greater extent than the natural land cover they replace (RSA, 1998, Part 4). To date, commercial forest plantations are the only declared SFRA, with other land uses under investigation either currently (e.g. sugarcane) or in future.

The Reserve and SFRAs take on core functions in the water authorisation and allocation process and in overall water management. Both have to be reviewed every five years (RSA, 1998).

Moreover, the NWA includes organisational changes and, importantly, legislation for the establishment of Catchment Management Agencies (CMAs) and Water User Associations (WUAs). Both organisations reflect the catchment as a spatial unit and a participatory-based approach to water management.

As a consequence, South Africa was delineated into 19 Water Management Areas (WMAs; with this number having been reduced to 9), each of which is designated to establish a CMA. Through these CMAs water resource management is delegated to the regional/catchment level and aims at including regional/local interests and knowledge. Therefore, the Agency's board must represent all stakeholders (including current and potential user groups) and their interests and seek cooperation and agreement on water-related matters (de la Harpe *et al.*, undated). Weston and Weston (2008, 25) describe these as "critical to [the] delivery of equitable, sustainable and efficient water services". This is true, as the CMA is the 'space' where guidance is given through national water

policies, but specific catchment characteristics (e.g. the environmental set-up, historical levels of development) and stakeholder needs (societal and economic) are considered in aiming at catchment-tailored development plans such as the legally binding Catchment Management Strategy (CMS).

WUAs represent water users "with a common interest that co-operate in undertaking water related activities at the local level for their mutual benefit" (de la Harpe *et al.*, undated, 39). Most of the already established WUAs are transformed former irrigation boards. This could be problematic as specific interests (e.g. water licences for irrigation, focus on water supply) might be overemphasised. Moreover, equity in knowledge will not be a given and minorities (e.g. subsistence farmers, rural people) might feel marginalised.

In conclusion, most characteristics of the NWA – the right to water by humans and the environment, the land-water link, catchment based management processes and five-year review cycles – are an excellent starting point to assess the potential impacts of climate change and include appropriate flexible actions and learning processes in an ongoing and responsive way.

2.7.3 The National Water Resource Strategy of 2004[6]

The objective of the National Water Resource Strategy (NWRS) is to take the NWA a step further towards a more practical and detailed document. Hence, it pushes implementation of the NWA as a challenging piece of legislation. Furthermore, the NWRS has to be reviewed and rewritten every five years. [The NRWS of 2004, due for updating in 2009, was only revised and finally published in 2013.]

One of the core pillars of the NWRS is that successful water resources management will depend on cooperation among all spheres of government, the active involvement of water users, other organisations and stakeholders, and IWRM (DWAF, 2004). It gives high priority to harmonious relations over water with neighbouring states, and thus includes for the provision of water to meet international rights and obligations. Another important aspect of IWRM is the aim of "building a society free from poverty and discrimination" (DWAF, 2004, 12).

[6]At the point in time of publication the NWRS 2004 was the only one available. The second NWRS was only published in 2013.

However, the NWRS only superficially considers climate change in very general terms as part of a sub-chapter (NWRS, Chapter 2.6). *Inter alia*, the statement is made that 'the future will not be a simple extension of the past'. Land use and climate change, both independently and interdependently of one another, are stated as being the "two key influencing factors with respect to resource availability" (DWAF, 2004, 49), and thus may be causing additional, but as yet unknown, variability in the future.

The strong focus of the NWRS on participatory processes, IWRM, interdepartmental communication and a holistic view would strongly support an adaptive management regime as described previously. The fact that the water system is seen to underpin changes due to climate change is well recognised by government and provides a window of opportunity to review and make necessary adjustments to governance[7] and policy.

2.7.4 International obligations

The post-1994 water legislation of South Africa has been consultative and includes lessons learnt from internationally integrated approaches (Seetal and Quibell, 2005). Water resource management and social development are strongly influenced by international donors and NGO activities, and have raised South Africa's policies to meet an international benchmark.

Furthermore, South Africa has exposed itself to international auditing when ratifying the Kyoto Protocol (UN, 1998) in mid-2002. This has lead to certain obligations for South Africa and has triggered an increasing integration of climate change aspects into discussions, regulations and reviews of a wide range of South African governmental institutions and political discussions (see Section 2.7.1).

Two years after passing the NWA, the Millennium Development Goals (MDGs) were signed off in 2000 by the UN Treaty Countries. Many of the MDGs have a direct water dimension (e.g. MDG 7, Environmental Sustainability) or an indirect one (e.g. MDG 1, End Poverty and Hunger, MDG 3, Gender Equality and MDGs 4 and 5, Child and Maternal Health). If these goals could be partially achieved, the high vulnerability of the poor in the water context could be substantially reduced, which could push the overall adaptation agenda. As the MDGs in South Africa also stand for overcoming many

[7] Governance here is understood as the interaction between the governmental institutions (constitution, legislature, executive and judiciary) with civil society (The Governance Working Group, 1996).

issues of the apartheid legacy (e.g. access to safe drinking water, poverty reduction, food security), political pressure to achieve them is high. However, according to evaluations in 2004 and 2007, South Africa has not made sufficient progress (UN, 2007). Achieving the MDGs will be even more of a challenge now that climate change is becoming part of the equation.

2.7.5 Beyond the water sector

Like the NWRS, the National Climate Change Response Strategy (NCCRS) was published by the Department of Environmental Affairs and Tourism (DEAT) in 2004. Based on the obligations of the Kyoto Protocol and the UNFCCC, it is a national policy roadmap and explicitly lists, albeit vaguely, some key actions on sustainable water management in the context of climate change (DEAT, 2004). Additionally, DEAT intends to publish a long-term national climate policy and a National Adaptation Plan that will address gaps in the current knowledge base. The central idea is that a significant loss in GDP could occur if key environmental assets, including South Africa's natural heritage, are not looked after, especially the more threatened ecosystems and conservation areas and marine resources, as well as ecosystem goods and services that support many livelihoods and maintain South Africa's environmental health and integrity (DEAT, 2004). Hence, this is a document with a promising future, provided that it is integrated into regulations and other legal documents.

Furthermore, a Climate Change Research and Development Strategy for South Africa was at time of writing this paper in 2010 at the draft stage under the auspices of the Department of Science and Technology (DST). This strategy aims to foster and enhance knowledge on climate change impacts and overall awareness and capacity, as well as resilience in response to climate change.

Many initiatives are thus being developed, all pushed by strong political commitments. However, these tend to stay on a national policy level and to date there has been little effort on implementation. The following section takes a closer look at the current status of the water management sector and how it is dealing with these policy strategies.

2.8 Current Status of Water Management

Much of South Africa's water management governance and infrastructure is based on historical colonisation and settlement processes as well as apartheid policies favouring

water delivery to certain sectors. A strong technocratic understanding and approach to water use (Weston and Weston, 2008), combined with a domination of engineering and economic knowledge (Colvin *et al.*, 2008), has historically led to a technical control paradigm, which manifests itself in:

(a) a total of 4,429 registered dams by July 2008 (each with capacity >50,000 m^3 and/or wall heights >5 m);
(b) more than 20 major inter-basin transfer schemes (DWAF, 2002);
(c) higher education in hydrology up to the 1980s traditionally being the domain of engineering faculties; and
(d) strong historical support for cloud seeding and artificial groundwater recharge.

Such a strong orientation towards technical supply in water management leads, *inter alia*, to a centralized management approach, and lack of integration and management of the source of problems compared to effects (Pahl-Wostl, 2008).

However, added to the many challenges to infrastructural development and maintenance that South Africa faces (Swatuk, 2008) comes innovative new legislation and a significant change in management approaches for South Africa's water managers (Section 2.7). Although an expert evaluation of the responsible Department of Water Affairs and Forestry [now Department of Water and Sanitation] in 2004 states that vast amounts of work have been carried out (de Coning and Sherwill, 2004), shortcomings exist with respect to policy coordination and regulation, as well as coherence with other South African policies. In the IWRM as well as the climate change context, the coherence of policies and enforcement of regulations are key needs and competences (Pahl-Wostl, 2007; Sadoff and Muller, 2009). Therefore this shortcoming is problematic in South Africa.

Overall, South Africa's legal environment and policies have been well developed. However, current implementation is "uneven, inconsistent and often inadequate" (Pegram *et al.*, 2006, iii). Furthermore, on-going institutional reform and changes in the legal and policy environment, combined with the loss of many experienced water managers (which diminishes institutional memory), have resulted in instability and reduced predictability of governance (Pegram *et al.*, 2006; Schreiner *et al.*, 2009). Additionally, many different analyses show that there is a lack of capacity building and institutional development in the field of IWRM (Muller, 2007; Schreiner *et al.*, 2009). This is exacerbated by under-resourced state departments and a varied understanding of the still on-going reform process (Colvin *et al.*, 2008). Furthermore, conceptual clarity

is lacking on how to implement IWRM, which, among other issues, leads to regression into a water management approach driven by supply and sanitation as well as infrastructure development (Jonker, 2007). Such a sectoral view is also apparent in the water allocation reform, which is a strongly politically driven process. As Jonker (2007) argues, this process has been 'reduced' to making water available for only one part of society (i.e. black farmers).

The lack of implementation of the NWA stands out as a core problem for adaptation in water management (Hattingh *et al.*, 2004; Pegram *et al.*, 2006; Colvin *et al.*, 2008), as does the lack of skilled decision-makers in the water sector (Hattingh *et al.*, 2004; Schulze, 2007; Weston and Weston, 2008; Schreiner *et al.*, 2009). Most crucial has been the failure to provide free basic water supply and sanitation (FBW) countrywide. Tissington *et al.* (2008) argue that this is due to the absence of 'any real national monitoring or enforcement'. This is of great concern, as increasing disparity results in increasing inequity and injustice and, consequently, increased vulnerability.

From an institutional perspective, there is already a significant weakening of the legal system in South Africa owing to the slow implementation of the CMAs as stipulated in the NWA (see Figure 2.3). Only very few have been, or are about to be, implemented[8]. This is also valid for the WUAs, albeit to a lesser degree. Decision-making processes have become difficult and are sometimes hindered by lack of leadership and ambiguities in responsibility (Schreiner *et al.*, 2009). Local knowledge is not always officially represented on boards or committees and so is not taken into account in decision-making, development planning, etc. (Jonker, 2007; Colvin *et al.*, 2008). The necessary stakeholder participation and cross-sectoral integration within a catchment does not always take place. Hence, catchment management strategies as the main planning documents for the catchments are, for the most part, still absent, leading to a lower level of knowledge specific to the catchment and its peoples. This excludes the two CMAs currently (2015) operating, *viz*. the Breede Overberg and Inkomati CMA.

[8] Nine proposals from 19 Water Management Areas have been submitted, out of which only five have been established to date (www.dwaf.gov.za/documents.asp?Notices , cited 20 February 2009).

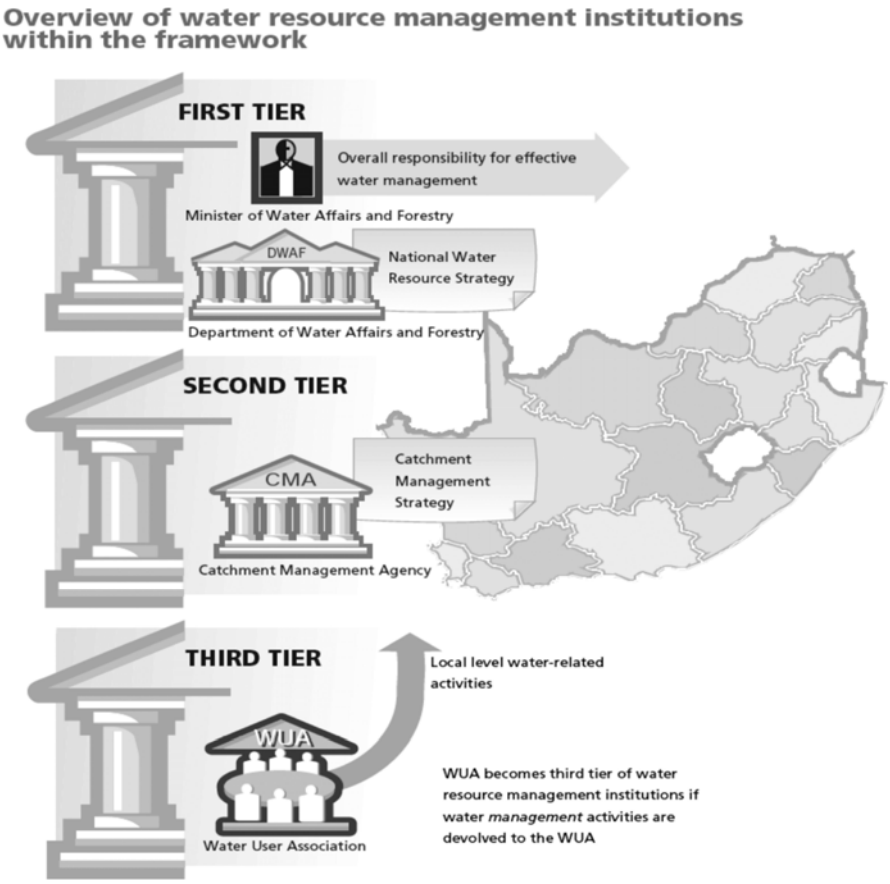


Figure 2.3 South Africa's institutional format as regulated under the National Water Act and National Water Resource Strategy (de la Harpe *et al.*, undated)

In combination with an inadequate regulatory and governance monitoring system, this, not surprisingly, has led to a progressive degradation of South Africa's natural resources, the country's water systems and specifically water quality (e.g. WRC, 2002; River Health Programme, 2004).

In the following section the discussion of the legal framework, as well as the current status of water management, will be assessed by means of a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. This is done against the characteristics, established earlier in this paper, on needs for an adaptive (4 – 7) and integrated (8 – 12) management approach that is focused on reducing vulnerabilities (1 – 3) to impacts of climate change.

2.9 A SWOT Analysis of South Africa's Laws and Policies

The past has shown that assessments of the potential impacts of climate change on South Africa's society, environment and economy have been inadequate. Political commitment is a main trigger for adaptation and transformation. Therefore, although the South African government has in the past few years increasingly talked about climate change and adaptation and mitigation, up to 2009 [i.e. at the time of writing this paper] there has been no direct funding available for the implementation of developed strategies, nor for adaptation *per se*.

2.9.1 Strengths

The main strengths are the recurring five-year review cycles, not only of water licences and authorisations, but also of key documents such as the NWRS and the CMSs. This offers an opportunity to review and reprioritise water management as well as adaptation actions. Furthermore, if implemented continuously, this could offer several openings to build capacity on all levels of governance and participation. However, the legally compulsory revision in 2009 of the NWRS [which was only completed in 2013] was not undertaken and what is in theory a strength has in practice become a weakness.

The direct incorporation of IWRM principles in the NWA, which is stressed further in the NWRS, shows strong alignment with the characteristics on integrated management (see 8 – 12). The catchment focus, stakeholder involvement and participation are even taken a step further by the development of organisational structures such as CMAs and WUAs. The SFRAs represent the land-water link and with its consequences calls for a good understanding of the overall system and its interactions (i.e. (4) for a holistic view). Overall, water is high on the development agenda, not only because of the MDGs, but because of the basic right to water anchored in South Africa's constitution, which almost forces political commitment. If stakeholder involvement and public participation were a strong feature of all regulations, this would allow for a dynamic and therefore responsive approach. Furthermore, there is a specific focus on people and catchments in developing CMSs, carrying out water authorization and in licensing processes. This addresses the characteristics needed to tackle vulnerability issues (see 1 – 3), but in particular it links locally specific adaptation decisions with a catchment perspective and ensures that this is embedded into national policy.

2.9.2 Weaknesses

As described in Section 2.8, water management in South Africa suffers from a severe shortage of skills and capacity and a lack of implementation efforts in the CMAs and other water institutions. The assessment identifies this as the main weakness. If a lack of implementation persists, this will be a major threat for the overall aims of water management as stated in the Constitution and the NWA. The same goes for the lack of policy enforcement due to understaffing and lack of capacity.

South Africa does not yet have an empowered civil society in all sectors (Schreiner *et al.,* 2009). Combined with the above, this might lead to reduced political will to drive the implementation and enforcement agenda, because an empowered civil society is indispensable for strong and effective public participation.

Additionally, a previously strong focus on water supply and water infrastructure leads to the known downfalls of a technical control paradigm. Furthermore, open information systems (7) and specific communication plans are not yet in place.

2.9.3 Opportunities

Nevertheless, there are many clear opportunities, such as an almost nationwide implementation of impact assessments in catchments as well as the availability of finances for research and consulting. Most importantly, however, are the five-year review cycles that are stipulated in many sections of the NWA, for example on water authorisations and licences, and the entire document of the NWRS that is to be rewritten every five years. These features strongly represent the characteristics called for in the adaptive capacity context (4 – 6).

2.9.4 Threats

Referring not only to Section 2.8, but also to the overall political and economic situation in South Africa, threats of poor governance and economic uncertainties exist. Furthermore, the Department of Water Affairs has begun questioning the principles of IWRM and has consequently developed (2009) a framework titled Water for Growth and Development. This will support and probably institutionalise the overall fallback into sectoralism (Jonker, 2007) and hence the strengthening of the old paradigm of keeping expert knowledge within specific institutions and away from politics (Vogel *et*

al., 2007). A lack of funding for explicit adaptation actions could even lead to an increase in existing inequalities. Again, this would be a severe setback to South Africa's transformation and efforts to undo the legacy of the past.

2.9.5 A national framework to deal with weaknesses and threats

The above analyses of South African laws, regulations and policies show that strengths are based mainly on written rules and regulations, while weaknesses partially reflect a de-skilling in government departments, relatively ineffective public participation and non-implementation of water legislation. Opportunities include the government's commitment to incorporate climate change and good governance. Threats include economic issues and an absence of best practice in IWRM, which (among other issues) have led to a questioning of the IWRM approach. A further fallback into sectoralism would make an integrated, sustainable, adaptation-oriented approach almost impossible. Implementing the unique and cutting-edge elements of South Africa's regulations remains an underlying challenge in all areas.

Hence, South Africa's regulations do offer a unique and flexible format to proactively adapt to climate change. This includes tools to initiate review processes and create catchment-tailored adaptation management plans that reflect specific needs, such as human resource management, monitoring and relevant participation. But weaknesses and threats could close the windows of opportunity that should be urgently taken advantage of. If such opportunities are not exploited, South Africa might fall back into a water management regime oriented to technology and supply that does not cover all aspects of society and the economy. Whoever profits from this, climate change will further increase vulnerabilities and, therefore, inequalities within society. A careful assessment of available institutional and individual capacities is needed. An opportunity to create innovative pathways to overcome these weaknesses and threats is described below, that is, a national framework for mainstreaming climate change into water management.

As stated above, adaptation and hence adaptive capacity call for responsiveness as well as the continual uptake of new information into decision-making processes in order to evaluate the negative effects and potential benefits of climate change (Muller, 2007). Detailed information on the levels of vulnerability is a key issue. This calls for the incorporation of a range of regularly updated data, knowledge and analyses leading to specific activities that reduce vulnerability. Moreover, uncertainties that will always

surround data, information and analytical tools must be taken into account (Pahl-Wostl, 2007). Integrating such information calls for dialogue and coordination (TEC GWP, 2004b) in order to "make choices consciously rather than by default" (Vogel *et al.*, 2007, 351). This in turn requires dynamic, well-informed organisations that offer leadership that can create effective strategies to adjust to changing circumstances (Muller, 2007).

Thus a 'space' is required where local and regional knowledge and needs meet policy guidance and management expertise. This space would be within the 'bigger picture' of water management, meaning it would be based on the IWRM approach. By including adaptive management criteria, such a space best lies at the catchment scale. In South Africa, CMAs should offer this space and leave enough flexibility to tailor activities even at the sub-catchment scale. This would ensure that the needs and views of the different participants are understood and, in the end, sum up to a holistic strategy.

The analogy of a pressure cooker can illustrate this process: local authorities and water users produce pressure from the bottom, and a 'lid' is provided by guidance from national policies and laws in addition to political agendas represented by the national and regional offices of the Department of Water Affairs. Leadership will have to be given by 'champions' within the relevant institutions and relevant stakeholder groups of the catchments. These champions create an arena for dialogue within the catchment, and negotiate scientific insights and create outcomes based on local knowledge, with a focus on livelihoods and existing vulnerabilities. In the context of South Africa's apartheid legacy, principles of equity must be placed up front in order to fully and fairly identify vulnerabilities (Adger, 2006) and at the same time to address uneven power relations (Colvin *et al.*, 2008).

2.10 Conclusions

South Africa's water regulatory framework offers a unique and flexible format to proactively adapt to climate change. The five-year review cycles offer a continual window of opportunity to reassess and redo not only adaptation actions, but also overall management approaches and implementation. However, weaknesses and threats should not be underestimated. Existing vulnerabilities and inequalities might be reinforced by a fallback into sectoralism and an impact-seeking public participation approach.

However, South Africa not only has a progressive set of recently promulgated water regulations, but it also needs to build new organisations and structures. Implementing such new approaches is a long-term process (Sadoff and Muller, 2009) and will have to include adjustments to water infrastructure to take in downstream impacts and local inhabitants in the water management process. Major changes, which go as far as changing decision-making processes, are often experienced as a threat by different groups. Water managers (i.e. governmental officials in their day-to-day working environment) could feel insecure and resist change, despite understanding the need for it (TEC GWP, 2004b). Progress in implementation is slow in South Africa, but it can [already] be seen today. If combined fairly and transparently with the transformation agenda, and not favouring particular groups or sectors (e.g. black farmers; small-scale and emerging agriculture), then synergies can be created and vulnerabilities reduced on a wide scale to enable adaptation and build adaptive capacity.

All the above points must be considered when mainstreaming climate change into water management. This paper explores the legislative components, and partially the governance arrangements and organisational operations required to move into a horizontally and vertically integrated management approach. If a new direction were taken, as this paper suggests, then further research is required to analyse the day-to-day reality of decision-making among water managers and experts in South Africa.

2.11 References

Adger, W. N., 2001. Scales of governance and environmental justice for adaptation and mitigation of climate change. *Journal of International Development*, 13. 921–931.

Adger, W. N., 2006. Vulnerability. *Global Environmental Change*, 16. 268–281.

Colvin, J., Ballim, F., Chimbuya, S., Everard, M., Goss, J., Klarenberg, G., Ndlovu, S., Ncala, D. and Weston, D., 2008. Building capacity for co-operative governance as a basis for integrated water resource managing in the Inkomati and Mvoti catchments, South Africa. *Water SA*, 34(6). 681–690.

De Coning, C. and Sherwill, T., 2004. *An Assessment of the Water Policy Process in South Africa (1994 to 2003).* WRC Report No. TT232/04, Water Research Commission, Pretoria, South Africa.

de la Harpe, J., Ferriera, J.-A. and Potter, A., Undated. *Water Management Institutions Overview*. Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Environmental Affairs and Tourism (DEAT), 2006. *South Africa Environment Outlook.* A Report on the State of the Environment. Executive Summary and Key Findings. Department of Environmental Affairs and Tourism, Pretoria, South Africa.

Department of Environmental Affairs and Tourism RSA, 2004. *A National Climate Change Response Strategy for South Africa.* Department of Environmental Affairs and Tourism, Pretoria, South Africa.

Department of Water Affairs and Forestry, 2002. *Inter-Basin Water Sharing to Achieve Water Security – A South African Perspective.* Speech by Director-General M. Muller. The Hague, The Netherlands. www.dwaf.gov.za/Communications/ Departmental%20speeches/2002/hague%20transfer%20final.pdf (Accessed 21 January 2009).

Department of Water Affairs and Forestry RSA, 1996. *Water Law Principles*. Pretoria, South Africa.

Department of Water Affairs and Forestry RSA, 2004. National water resource strategy. *Our Blue Print for Survival* (1st edn). Pretoria, South Africa.

Gallopín, G. C., 2006. Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, 16. 293–303.

Hattingh, M. J. G., Turton, A., VanWyk, E. and Oelofse, S., 2004. Environmental governance and equity in a democratic South Africa. *Water Governance for People & Nature: What Roles for Law, Institutions, Science and Policy?* American Water Resources Association International Specialty Conference, 29 August–2 September 2004. IWLRI, University of Dundee, Dundee, Scotland. 1–9.

Ionescu, C., Klein, R. J. T., Hinkel, J., Kavi Kumar, K. S. and Klein, R., 2005. *Towards a Formal Framework of Vulnerability to Climate Change.* FAVAIA Working Paper 1 (NeWaterWorking Paper 2), Potsdam Institute for Climate Impact Research, Potsdam, Germany.

IPCC, Working Group 1, 2007a. Climate change 2007: The physical science basis. Summary for policymakers. *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland.

IPCC, Working Group 2, 2007b. Climate change 2007: Climate change impacts, adaptation and vulnerability. Summary for policymakers. Working Group II *Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report*. Geneva, Switzerland.

Jonker, J., 2007. Integrated water resources management: The theory-praxis-nexus, a South African perspective. *Physics and Chemistry of the Earth*, 32. 1257–1263.

Kabat, P. and van Schaik, V. (co-ordinating lead authors), 2004. *Climate Changes the Water Rules: How Water Managers can Cope with Today's Climate Variability and Tomorrow's Climate Change*. Dialogue on Water and Climate, Netherlands.

Lumsden, T. G., Schulze, R. E. and Hewitson, B. C., 2009. Evaluation of potential changes in hydrologically relevant statistics of rainfall in Southern Africa under conditions of climate change. *Water SA*, 35(5). 649–656.

Mertz, O., Halsnaes, K., Olesen, J. E. and Rasmussen, K., 2009. Adaptation to climate change in developing countries. *Environmental Change*, 43. 743–752.

Moser, S. C., 2010. Now more than ever: The need for more societally relevant research on vulnerability and adaptation to climate change. *Applied Geography, 30*. 464-474. doi:10.10.16/j.apgeog.2009.09.003.

Muller, M. (lead author), 2007. *Climate Change Adaptation and Integrated Water Resource Management: An Initial Overview*. Policy Brief 5 of the Technical Committee (TEC) GWP, Sweden.

Pahl-Wostl, C., 2007. Transitions towards adaptive management of water facing climate and global change. *Water Resource Management*, 21. 49–62.

Pahl-Wostl, C., 2008. Requirements for adaptive water management. *Adaptive and Integrated Water Management: Coping with Complexity and Uncertainty*, C. Pahl-Wostl, P. Kabat and J. Mo¨ltgen (eds). Springer Verlag, Germany. 1–22.

Pegram, G., Mazibuko, G., Hollingworth, B. and Anderson, E. 2006. *Strategic Review of Current and Emerging Governance Systems Related to Water in the Environment in South Africa*. WRC Report No. 1514/ 1/06, Water Research Commission, Pretoria, South Africa.

Republic of South Africa, 1996. *Constitution of the Republic of South Africa*. Act 108 of 1996, amended on 11 October 1996 by the Constitutional Assembly. Government Printer, Pretoria, South Africa.

Republic of South Africa, 1998. *National Water Act. Act.* No. 36 of 1998. Government Printer, Pretoria, South Africa.

River Health Programme, 2004. *State-of-Rivers Report: Berg River System*. Department of Water Affairs and Forestry, Pretoria, South Africa.

Sadoff, C.W. and Muller, M., 2009. *Perspectives on Water and Climate Change Adaptation*. Better Water Resources Management – Greater Resilience Today, More Effective Adaptation Tomorrow. A Perspective Paper contributed by the Global Water Partnership through its Technical Committee. Sweden.

www.gwpforum.org/gwp/library/Planning_Better_WRM.pdf (Accessed 5 November 2009).

Schreiner, B., Pegram, G. and von der Heyden, C., 2009 (unpublished). Reality check. *Water Security: A Water Agenda for DBSA to Prepare for the Third Decade of Democracy*. Research and Information Division Development Bank of Southern Africa (ed.). South Africa.

Schulze, R. E., 2003. *The Thukela Dialogue: Managing Water-related Issues on Climate Variability and Climate Change in South Africa*. Report to 'International Dialogue on Water and Climate'. University of Natal, School of Bioresources Engineering and Environmental Hydrology, ACRU cons Report 44. Pietermaritzburg, South Africa.

Schulze, R. E., 2007. Some foci of integrated water resources management in the 'South' which are often forgotten by the 'North': A perspective from southern Africa. *Water Resources Management*, 21. 269–294.

Schulze, R. E., 2008. Integrated water resources management as a medium for adapting to climate change: Conceptual, scaling, impacts modelling and adaptation issues within a southern African context. *Towards Climate Change Adaptation: Building Adaptive Capacity in Managing African Transboundary River Basins*, T. Petermann (ed.). Zschortau, Germany. 41–63.

Seetal, A. R. and Quibell, G., 2005. Water rights reform in South Africa. *Water Rights Reform: Lessons for Institutional Design*, B. R. Bruns, C. Ringler and R. Meinzen-Dick (eds). IFPRI, Washington, DC, USA. 153–166.

Swatuk, L. A., 2008. A political economy of water in Southern Africa. *Water Alternatives*, 1(1). 24–47.

Technical Committee (TEC) GWP, 2004a. *Policy Brief: Unlocking the Door to Social Development and Economic Growth: How a More Integrated Approach to Water can Help*. Stockholm, Sweden.

Technical Committee (TEC) GWP, 2004b. *Catalyzing Change: A Handbook for Developing Integrated Water Resources Management (IWRM) and Water Efficiency Strategies*. Stockholm, Sweden.

The Governance Working Group of the International Institute ofAdministrative Science, 1996. *A Definition of Governance*. www.gdrc.org/u-gov/governancedefine. html (accessed 8 December 2008).

Tissington, K., Dettmann, M., Langford, M., Dugard, J. and Conteh, S., 2008. *Water Services Fault Lines.* An Assessment of South Africa's Water and Sanitation Provision across 15 Municipalities, Johannesburg, South Africa. Report released

by Centre of Applied Legal Studies (CALS), Centre on Housing Rights and Evictions (COHRE) and Norwegian Centre of Human Rights (NCHR).

United Nations, 1998. *Kyoto Protocol to the United Nations Framework Convention on Climate Change.* Signed on 11th December 1997. Kyoto.

United Nations, 2007. *Africa and the Millennium Development Goals 2007 Update*. UN Department of Public Information. DPI/2458.

University of Copenhagen, 2009. Press release 'Key Messages from the Congress', 12 March 2009. *International Scientific Congress on Climate Change, Global Risks, Challenges & Decisions*. Copenhagen, Denmark. www.climatecongress.ku.dk/newsroom/congress_key_messages/ (accessed 15 March 2009).

Vogel, C., Moser, S. C., Kasperson, R. E. and Dabelko, G. D., 2007. Linking vulnerability, adaptation, and resilience science to practice: Pathways, players and partnerships. *Global Environmental Change*, 17. 349–364.

Water Research Commission (WRC), 2002. *State-of-Rivers Report uMngeni River and Neighbouring Rivers and Streams*. WRC Report TT 200/02, Water Research Commission, Pretoria, South Africa.

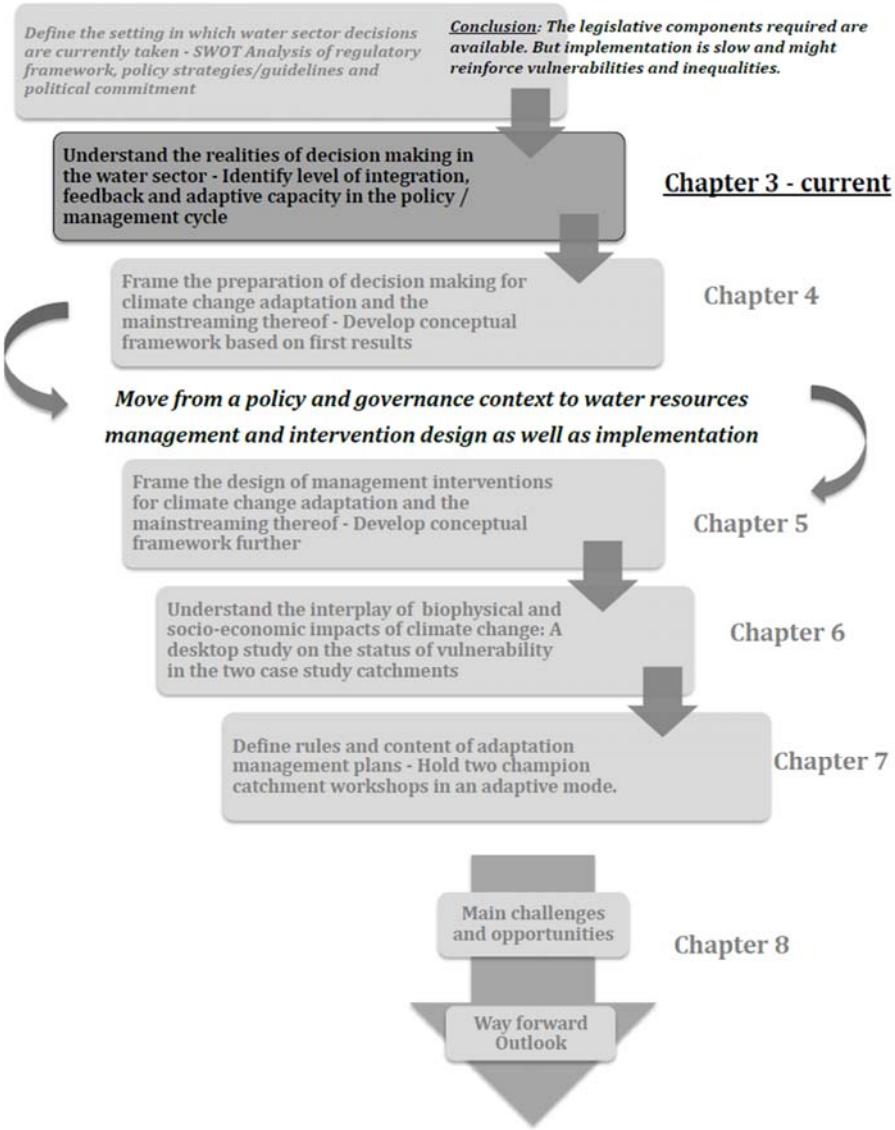
Weston, B. and Weston, D., 2008. South Africa's journey to equity, sustainability and efficiency. *Environmental Scientist*, 17(3). 24–26.

3. A SNAPSHOT OF SOUTH AFRICA'S WATER RESOURCE MANAGEMENT STATUS: WHAT DOES THIS INDICATE FOR OVERALL WATER GOVERNANCE?

S.I. Stuart-Hill and R.E. Schulze

Centre for Water Resources Research; School of Agricultural, Earth and Environmental Sciences; University of KwaZulu-Natal, Pietermaritzburg, South Africa

At the time of submission of this thesis (March 2015) this chapter was in preparation for submission to the *Journal of Environmental Management*. Accordingly the referencing convention adheres to the rules of that journal.



3.1 Abstract

The legal framework of a country is only a canvas upon which management and governance unfolds. It is especially when laws, regulations and policies are rewritten and include major shifts in thinking and in decision-making that management, implementation, and a full comprehension by water users of the implications are often lagging behind. South Africa is considered such a case in point: When exploring the legislative components of its water regulatory framework, it offers a unique and flexible format to understand existing, as well as emerging, vulnerabilities in order to proactively adapt. Hence, a reality check was undertaken by conducting 34 semi-structured interviews with experts, decision takers and stakeholders in the South African water sector. The outcomes of the interviews aim at an analysis of the manner in which the "water executive" functions within the governmental arrangements of water resources management, as well as how it interacts with stakeholders and civil society. On the one hand a major challenge remains the uneven management and governance landscape in regard to many of the issues assessed, *viz.* integrative and holistic thinking, law enforcement, capacity issues of different types, and ineffective communication with stakeholders. On the other hand, while not a systemic issue, political pressures and interference seem to exist in several cases. The results indicate that a paradigm shift from the previous technological control paradigm is starting to take place, if not everywhere, then at least in parts of the water management system. However, the process is seen as extremely slow and fragmented.

Key words: Adaptive water management, South Africa, capacity, and interviews

3.2 Introduction

Much has been written about concepts of water management and governance, as well as on organisational operations and institutional issues. However, the realities of actual decision-making, intervention design and their respective implementation have to be seen in a wider context than the water sector only, or the context of a specific location, and these realities have seldom been interrogated (Eriksen and Lind, 2009; Berkoff, 2013). Integrated Water Resources Management is an example for such a wider context, in which successful implementation is linked to three pillars, *viz.* an enabling legislative environment, an appropriate institutional framework and a tailored set of management instruments (Agarwall *et al.,* 2000). However, as Medema *et al.* (2008, 4) conclude,

these pillars “are not sufficiently detailed or prescriptive to fully specify how to realise the claims of the framework”. Even the detailed ‘To-Do-Lists’ by some authors (e.g. Grigg, 2008) might not be applicable to the realities of decision-making and intervention design and its implementation. Furthermore, the aim of water management should be to optimise and improve its performance over time (Mickwitz, *et al.*, 2009, 16). This will need to be reflected in decision-making beyond the design of policies, regulations and instruments, and will need to reflect in the overall sustainable development of a country’s water resources (Someshwar, 2008). Thus, elements of decision-making and implementation are at the core of this paper.

The world is currently experiencing huge challenges based on the impacts of global change and, especially, of climate changes (e.g. Kabat, 2013) in regard to water resources management and, particularly, economic development. The resulting vulnerabilities to climate change and the need for adaptation is no longer being debated. Yet, these are anticipated to push organisations and individuals to their limits and calls for new ways of management, engagement and learning (Barnett, 2010; Ison *et al.*, 2011; Pahl-Wostl *et al.*, 2011; Huntjens *et al.*, 2012; Wieczorek and Hekkert, 2012). In order to deal with highly complex and uncertain drivers such as climate change and their impacts, “learning collaboratively, engaging politically and being self-reflective” are not only key concepts, but may create opportunities for institutional innovations (Woodhill, 2010, 53; Huppé *et al.*, 2012; Leach *et al.*, 2012). Hence, learning and particularly feedbacks will be crucial to management and implementation under the challenges of change (Pollard and du Toit, 2011; Never, 2012). Additionally, relevant participation by stakeholders and the public, and collaboration within and outside the water sector can enhance learning and performance (Folke *et al.*, 2005; Pahl-Wostl *et al.*, 2007a; Newig and Fritsch, 2009) and, therefore, will need to be part of this planned investigation.

Furthermore, management and governance unfold on the basis of legislative frameworks, policies and regulations (e.g. Ebbesson, 2009). It is especially when laws, regulations and policies are rewritten and include a major shift in thinking and decision-making that the management, implementation, and a full comprehension of the implications by water users are often lagging behind (Schreiner, 2013; Ténière-Buchot, 2013), or alternatively they face unintended and previously never-thought-of challenges (Foerster, 2011). Institutional constraints may hamper or limit adaptation not only within a single organisation, but in entire systems (Inderberg and Eikeland, 2009), in this case the water sector. This is where learning and knowledge management as well as

every-day routine-based activities play a crucial role (Roux *et al.*, 2008; Inderberg and Eikeland, 2009) if integrative, adaptive and sustainable water management are to be achieved. All of this must be seen in a context relating not only to national policies (Berkoff, 2013), but also to local water management and the resulting interventions that are likely to unfold with all their complexities on a more local scale (Urwin and Jordan, 2008; Barnett, 2010). Hence, the circumstances of decision-making need to be understood in a context of how these influence the wider environment of water governance[1] and its sector within which water management is embedded. Thus, already informed actors and decision-makers as well as those experiencing the outcomes of decision-making have to be part of this investigation. The key research question, therefore, is "How are water management decisions actually taken nowadays and how do these decisions, and also the environment they are embedded in, relate back to the overall state of water management and governance?"

Based on the challenges ahead of water management having to deal with rapid and complex change patterns, as alluded to earlier, the following needs of water management have been identified by Stuart-Hill and Schulze (2010):

(a) understanding vulnerabilities, both current ones as well as emerging ones,
(b) integrating all aspects of hydrological responses as well as the integration of stakeholders involved,
(c) displaying flexibility and preparedness of uptake of new information into decision making, and
(d) including participation of effective institutions in knowledge building and decision-making.

Overall, this calls for an integrative management approach, in unison with adaptive organisations, individuals and decision-making (Stuart-Hill *et al.*, in preparation). This paper will, for the first time, undertake investigations in a specific case in order to understand the knowledge-creating and decision-making environment of water managers. For this undertaking, a Policy-Management Cycle has been designed, which structures the investigation according to the needs alluded to in this section, *viz*. integration, adaptation and learning. Furthermore, for the first time, focus has been directed onto the characteristics of feedback and learning within governmental water resources management.

[1] Governance is understood here by the definition of Pahl-Wostl *et al.* (2012, 25): "The notion of governance takes into account the different actors and networks that help formulate and implement water policy. Governance sets the rules under which management operates."

3.3 The Case of South Africa

As commented upon earlier, the institutional format and legislative framework of a country is only the formal canvas on which water management and governance takes place. Even when an enabling environment exists, but law enforcement and overall implementation of the policies are lacking or are incomplete, the degradation of the resource base is highly probable (Ebbesson, 2009). This currently appears to be the case in South Africa, which displays promising water legislation to tackle challenges of societal transformation, growth and development, as well as future uncertainties (Seetal and Quibell, 2005; Swatuk, 2010; Schreiner, 2013), but is simultaneously experiencing drastic degradation in its water resources (CSIR, 2011). This implies that South Africa's capacity to implement effective water arrangements is poor (Iza and Stein, 2009), especially when taking into consideration the needs to implement IWRM as the main management approach, as set out in South Africa's National Water Act (Republic of South Africa 1998).

When exploring the legislative components of South Africa's water regulatory framework, specifically in regard to performing in an integrated and adaptive manner, it offers a unique and flexible format to understand existing as well as emerging vulnerabilities to proactively adapt to, for example, climate change (Stuart-Hill and Schulze, 2010). It even offers the flexibility to tailor regulations and water management to each specific catchment area.

Hence, a reality-check needs to be undertaken, which this paper aims at as shown in Figure 3.1. The research should show whether an integrated and adaptive management approach on a national scale is implemented and is cascading downwards onto finer scales, *viz.* provincial, catchment or local. Furthermore, the research should show whether any interventions which have been designed by governmental authorities are relevant to tackle the challenges lying ahead. By this, the research gives new insights into the failures of South Africa's drive to implement its innovative legal framework.

Figure 3.1 Deriving the research question(s) for this paper

The aim of the research undertaken here is to explore if the governmental arrangements in regard to water management, as well as interactions with society and other sectors, are functioning according to their intent, if existing and emerging vulnerabilities are understood, if leadership for learning and collaboration exists, and if participatory activities may be viewed as spaces of dialogue that ensure the success of the aforementioned steps and issues. This was done by undertaking a series of semi-structured interviews, via a questionnaire, with relevant players, i.e. water managers and decision-takers, in the South African water sector.

3.4 Methodological Approach

This section will be split into four components: the first on what needs to be analysed, *viz.* the policy-management cycle in regard to its potential for integration, learning, feedback and adaptation; the second, who was interviewed in order to gain some insight as to the response; thirdly, how the questionnaire was designed and used and, lastly, how the analysis was carried out in order to obtain results which would answer the research questions in Figure 3.1.

3.4.1 The Policy–Management Cycle

As discussed above, the adaptive capacity and the integrative potential of decision-making needs to be investigated. Decision-making takes place in regard to policies as well as in regard to day-to-day management. Furthermore, it is not only the approach, but also its overall level of actual implementation, that is of interest here. Thus, based on a diversity of research designs and results in regard to governance (e.g. Deason *et al.*, 2010; Loorbach, 2010; Woodhill, 2010), policy design (e.g. Benvie, 2005; Pahl-Wostl *et al.*, 2007b; Plummer and Slaymaker, 2007; Pahl-Wostl, 2009) and adaptive

management (e.g. Holling, 2001; Pahl-Wostl, 2006; Kingsford *et al.*, 2011) the so-called Policy-Management Cycle was designed as laid out in Figure 3.2. The main characteristics that make up the cycle are integrative understanding and decision design, and following from there learning, feedback and corresponding adaptation. It needs to be noted here, that Phases I, L and F as depicted in Figure 3.2 relate to the management dimension, while Phases F and A relate strongly to policy making. Only when the Policy-Management Cycle is closed, i.e. all phases are reflected strongly in the relevant decision-making processes around water resources management, can one speak of an implemented adaptive management approach that takes into consideration vulnerabilities, new information and participatory sense-making. This leads to the current status of the cycle, represented by n, to move to the next phase, n+1, then n+2, and so forth into the future, ensuring the optimisation of management performance as discussed under Section 3.2 and the overall mainstreaming of integration and adaptation into management within the water sector.

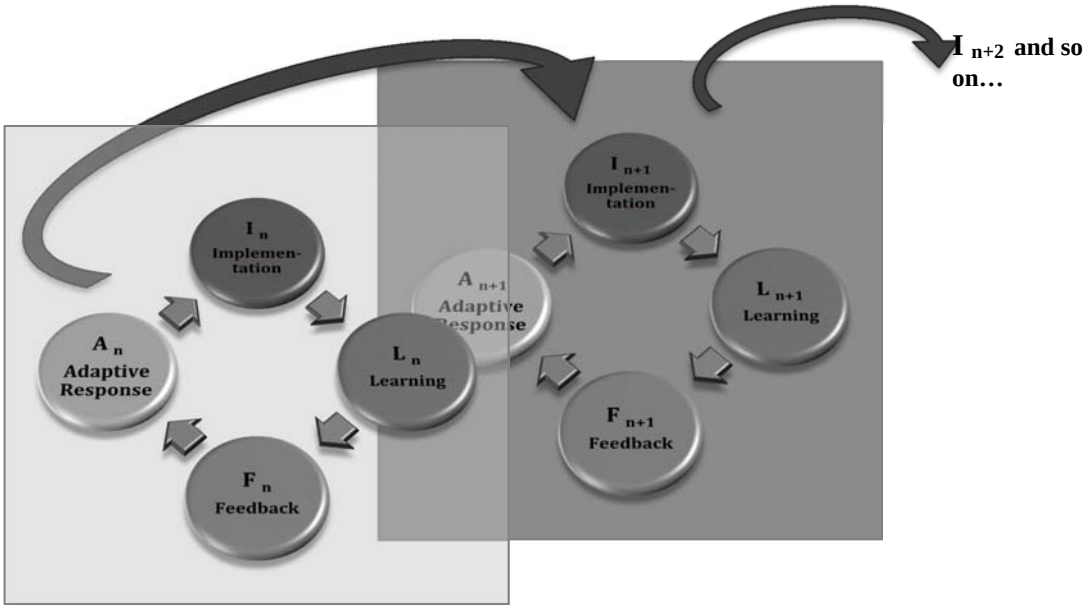


Figure 3.2 The Policy-Management Cycle

When this type of mainstreaming is embodied in water management then the potential is high that management interventions will deal with change and, specifically, with adaptation in a context of climate change and its vulnerabilities (Stuart-Hill and Schulze, 2010) and, consequently, will mainstream adaptation to climate change into the water sector (Stuart-Hill *et al.*, in preparation).

The Policy-Management Cycle applied in the context of the research undertaken by the authors consists of four phases:

(a) Phase I or I = How far is the holistic and integrated approach of water management implemented in South Africa?
(b) Phase II or L = Is learning by individuals in the governance system as well as in their decision-making environment possible?
(c) Phase III or F = Are there opportunities to feed that which has been learned back into the governance system?
(d) Phase IV or A = How far is this resulting in adaptation and changing of decisions taken to date? Or, to phrase it differently: how does this result in an overall adaptive management approach?

3.4.2 Interviewees

In order to gain insight into day-to-day decision-making realities by South Africa's water managers, 34 semi-structured interviews were conducted in 2009 and 2010. It could be argued that this sample is not a true representation of South Africa's water sector. However, the interviewees were chosen, based on their involvement in designing and implementing the water legislation as well as the characteristics alluded to in Section 3.2. All 34 interviewees had significant years of experience in the water sector (minimum 5 years, maximum 39 years). On average, the experience reflected in the answers is based on more than 20 years of involvement, understanding and know-how of South Africa's water sector. A sample of 34 was therefore seen as representative of the information and knowledge needed for the assessment. The interviews aimed at describing a status quo of decision-making[2] in the water sector (Flick *et al.*, 2003). The interviewees came from the governmental, consulting, academic and industrial sectors. In South Africa decision-making and its corresponding accountability rests mainly with government. However, government and its decision-making is being heavily advised by consultants (Schreiner, 2013); therefore, these two groups are strongly represented amongst the interviewees, by 13 and 10 respectively. Furthermore, certain academic leaders have been, and are still, involved in informing policy design and decision-making, e.g. membership in the South African COP delegations, National Advisory Committee to the Minister of Water Affairs. Thus, 8 influential academics were interviewed. Additionally, 3 interviewees originate from the industrial / private sector. It

[2] At the time of the interviews all interviewees had and/or were playing a significant role in strategic decision-making of the water sector. Based on the still strongly hierarchically-orientated water sector, water users and stakeholders seldom are part of actual decision-making and implementation.

needs to be noted here that in numerous cases interviewees have, meanwhile, moved between the sectors named above. Here the assumption has been made that once the individual has spent more than three years within the sector they presently operate in, he/she was assigned as 'belonging' to that sector. If not, then it was assumed that the knowledge base and framing of their answers to the questionnaire were influenced by their former employment, which in all cases in this survey represented the majority of the individual's work life experience. Only two re-assignments had to be made, with two current consultants having been formerly, i.e. less than 3 years ago, with national government and academia, respectively.

All interviewees approached were known to have been in the water sector for many years and some were even part of developing and writing the South African National Water Act of 1998. Furthermore, the individuals interviewed were either in leading managerial positions in government, or were heavily involved consultants who had close relationships to these and other decision-makers within government, or were influential thinkers from the academic and industrial sector.

3.4.3 Questionnaires

The questionnaire developed consists of four sections, the first two dealing with global questions investigating the integrative and adaptive potential, and the second two tailored specifically to the South African case:

(a) **Section A** evaluates the enabling environment in regard to policies, the legislative framework as well as financing and incentive structures. The aim of this section is to assess the *status quo* in regard to implementation of the National acts and policies, as well as implementing the principles of IWRM.

(b) **Section B** evaluates institutional roles and management instruments, first to again assess the *status quo* in regard to implementation of the relevant acts and policies as well as the principles of IWRM, but also to evaluate effectiveness of overall water governance.

(c) **Section C** performs a reality check for South Africa in regard to implementation of key policies, transformation and cooperation between sectors.

(d) **Section D** deals with issues of change, leadership, participatory management and adaptation. Here the aim is to assess barriers and drivers of change as well as cooperation within and beyond the water sector, and to integrate interests of users and decision-makers from all levels.

The questions of **Sections A, B** and Question 7 in **Section C** were founded on two Technical Briefs of the Global Water Partnership, *viz.* 1 and 3 (Carriger, 2006a; Carriger, 2006b), as well as the corresponding TEC Background Papers 3, 4 and 7 (Solanes and Gonzalez-Villarreal, 1999; Agarwall *et al.*, 2000; Rogers and Hall, 2003). As a result of the high level of expertise and recognition of the Global Water Partnership in all issues relating to policy design and implementation of IWRM, it appeared appropriate to relate to their characteristics and indicators they developed. With specific regard to the Policy Briefs used, these serve to inform about water resources management for policy makers and are written by the GWP Technical Committee. They are available as printed documents and have been successfully distributed to a wide audience of practitioners and scientists. The other questions of Sections C and D were tailored inquiries in regard to the implementation status and decision-making around South Africa's existing policies and regulations.

The **Sections A, B** and **C** of the interview always queried the level of alignment between 'what is on paper' (i.e. what should be) and 'how reality is presenting itself' (i.e. what is actually happening). Comments and elaboration on other issues were allowed in order to gain a better contextual and (partially) historical understanding.

3.4.4 Analysis

The interviewer took notes as well as recording the interviews in order to have a fall-back should a need arise for clarification of certain issues. As interviews varied in time between little more than one hour and three hours, it was decided not to transcribe these. All questionnaires were rendered anonymous before analysing any answers.

For this paper and its aims, a specific set of questions was chosen to represent core issues in fulfilling the four phases of the Policy-Management Cycle. Please refer to **Annexure 1** of this paper for the formulation of the individual questions and the full questionnaire. For the Integration Phase (I) these were Questions 2, 3, 7, and 11 from **Section A**; Questions 1, 2, 3, and 12 from **Section B**; and Questions 1 and 2 from **Section C**. These considered the level of integration of policies and frameworks, alignment of policies and organisations, cooperation between players and sectors, implementation levels of core policy tools, *viz.* the environmental and human reserves as embodied in the NWA (1998), water licensing, poverty measures and overall representation of IWRM in decision-making. For the Learning Phase (II) the questions were taken from numbers 6, 7, 8 and 20 of **Section B**, which reflect on issues of

capacity building, improvement of practices, collection and analysis of relevant data as well as the sharing of information. For the Feedback Phase (III) questions 9, 10 and 21 of **Section B** were selected as these relate to feeding back results into decision making and planning, communication of results and the availability of decision-support tools. For the Adaption Phase (VI) question 18 from **Section B** was used (effective cooperation). All other questions originated from **Section D** reflecting on the initiation, implementation, and evaluation of adaptive activities, the availability of leadership versus skills, as well as participatory knowledge management and decision making.

In only one section of Phase I were the interviewees asked to rate normatively the implementation of laws and policies as well as the reflection of IWRM in their daily work, with the rating being between 1 (not at all) and 5 (fully implemented). The authors rated all other answers, as it must be assumed that the interviewees would not have rated their daily performance and success objectively enough to gain useful insights into the daily water management processes. In none of the interviews more than 10% of the questions were left unanswered. The unanswered questions indicated a professionalism and integrity of the interviewees not to make judgement on issues beyond their field of knowledge. Only in the section on the capacity narrative was the unanswered percentage higher (16%). Overall the majority of unanswered questions originated from consultants and this can probably be linked to their limited insights into certain issues of governmental performance. Only a few from the government sector indicated no answer for their questions, with 8 unanswered questions in total from 48 questions per interview.

In the course of the analysis the well-known narrative from many personal conversations of “lack of capacity on all levels of South Africa’s water managers, especially those making decisions” came up on many different occasions. Hence, the interviewer included a section to investigate this capacity narrative. The analysis (see Section 3.4.3) was based on three different sections: a general capacity question that was asked in the early stages of the interview (**Section B**, question 5), the analysis of the strongest barriers that the interviewees listed in the later stages of the interview (**Section D**, question 5) and a more detailed section on human capacity (**Section D**, question 7 i-iv), which broke the matter down into four components of capacity, *viz*. political, professional, implementation and compliance capacity.

The overall aim of the interview process was to gain insight into the executive, and specifically the decision-making component of the water sector, including the

formalisation of interactions with stakeholders and civil society since this has become a strong focus of South Africa's post-apartheid legal framework. As alluded to earlier (*cf.* Section 3.2), this leads to a focus on governmental activities and functions. Three main areas of concern were targeted for the analysis presented in this paper, *viz.* (i) how far is the holistic and integrated approach of water management implemented (i.e. Phase I of the Policy-Management Cycle), (ii) is learning of individuals as well as feedbacks into the governance system possible (i.e. Phase II and III of the Policy-Management Cycle), and (iii) how far is this resulting in adaptation and an adaptive management approach (i.e. Phase VI of the Policy-Management Cycle)? In combination with other topics such as leadership, and especially when clarifying the capacity narrative, the decision making environment of the individual within the water sector was evaluated.

The results should allow an understanding to be gained of the *status quo* of the implementation of water policy developed post-1994 and how new challenges such as climate change are dealt with. Results should reveal how water resources issues are framed and understood, whether learning and feedbacks are possible in the framing as well as decision-making process, and if this results in adaptation of any scale in regard to knowledge creation or decision-making. Furthermore, overall levels and types of fragmentation should become evident when assessing the strengths and weaknesses of the Policy-Management Cycle as well whether the cycle is actually closed or not.

3.5 Results

All interviewees engaged well with the questions and gave detailed insights into South Africa's water governance and management system. Many commented that it was a very worthwhile and interesting exercise that made them reflect on many issues of the current system and its realities. In regard to the sectors from which the interviewees came, these represented the four currently most influential sectors on water resources management in South Africa, i.e. government, consultants, academia and industry, the latter to a more limited extent. No differentiation was made between different levels of government, *viz.* national, regional, and local. In South Africa the regional level is incorporated into the national structure and from the local level only very limited influence can be taken on water resources management, as it does not have any responsibilities in this sphere. Local level government is solely responsible for water services. However, one very influential champion, based on his being part of top management of a big metropolitan area, highlighted that his daily work and decisions constantly force him to migrate between water resources and water services.

It needs to be noted here that no correlation or patterns could be found between questions and the interviewee's sector representation, e.g. governmental players did not rate their performance higher than that of the others, and academia did not rate capacity issues significantly lower compared to other sectors. It seems that a homogenous picture with regard to the aspects discussed is being drawn up by the different practitioners and water managers, and it can thus be assumed that the information by the interviewees is complementary towards each other.

The results are presented for each phase that makes up the cycle in the following Section, *viz.* 3.5.1.

3.5.1 The Policy-Management Cycle

Phase I - Integration

As elaborated upon earlier, Phase I considers the integrative creation of knowledge and the integrative design of solutions. This phase is split into two main sections, one where the interviewees rated four questions directly on a 1 to 5 scale with 1=not at all implemented, 5=fully implemented, the other (with 10 questions) where an independent rating was undertaken by the interviewer. The independent rating was based on elements identified as crucial for the phase either being fulfilled entirely, or not at all, or only in a limited (intermediate) way. This approach does not only evaluate the strengths or weaknesses of this phase, but also whether the overall perceptions and experiences of the interviewees are consistent with reality.

In Phase I the independent rating shows that 36% of the interviewees rated the requirements of a holistic and integrated approach as being fulfilled (Figure 3.3). However, a similar number of interviewees, *viz.* 37%, rated the approach as only being fulfilled partially and with many limitations. The remaining 27% rated holism and integration as not being existent in the water sector.

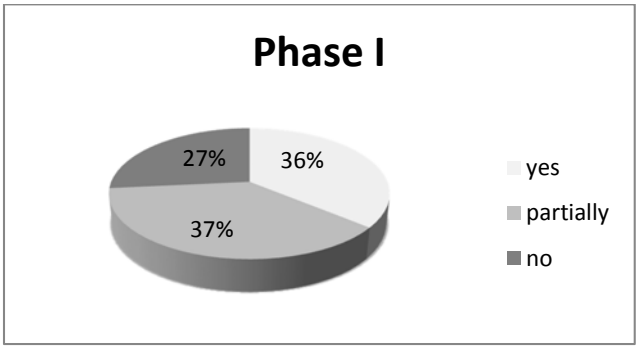


Figure 3.3 Independent rating in regard to the reflection of a holistic and integrated approach of water management in decision-making and implementation

Recurring (i.e. mentioned by > 5 interviewees) themes in the comments made in this phase were:

- Lack of capacity and skills exists in the decision-making environment.
- Different levels of implementation exist in different parts of South Africa.
- Formally South Africa's legislative and policy format is very good, but for various historical / political reasons is very challenging. Hence, only slow progress can be seen in its implementation.
- The lowest governmental level, *viz.* local and municipalities, are the most problematic in regard to implementing an integrated approach to water management.
- Many of the acts and policies are considered not to be aligned and lead to controversies or confusion.
- A high staff turn-over in the governmental departments on all levels has been identified as problematic.
- Not as often as the issues raised above, but mentioned a number of times, were examples of political pressures overriding management, as well as lack of political will in certain areas.

The highest level of agreement on fulfilment existed in regard to Question 12 in **Section B**, *viz.* that investments were too low in empowering and involving certain excluded social groups such as women and the poor. The highest level of disagreement on fulfilment existed in regard to Question 2 in **Section A,** *viz.* that economic and social policies take into account water resource implications.

In regard to the direct ratings on a normative scale of 1-5, as done directly by the interviewees, the results reflect that the implementation of the National Water Act

(NWA) was rated on average with a weak 2.6, which is almost 1 point lower than the rating of the Water Services Act (WSA) which came up with a relatively high rating of 3.4. The reasoning was often that the WSA is clearer in setting out its roles and responsibilities. The incorporation of the principles of IWRM in regulations was rated very high with a 4.0. However, as regulations are only as good as their implementation, and the actual relevant rating for incorporating IWRM in actual decision-making was considerably lower with a 2.8. This is slightly higher than the rating given to the implementation of the NWA.

It seems that the individual decision-makers in the water sector have started to incorporate the principles of IWRM in their values and, hence, their interventions. Yet, the organisational environment seems to be lagging behind with implementation.

Overall the perceptions of the interviewees reflected what is considered reality, with the overall performance of the water sector in regard to implementation of IWRM being rather weak in both cases, i.e. with the independent rating being 37% and the direct rating 2.8 out of 5.

Phase II - Learning

As elaborated upon earlier, Phase II considers if and how learning is possible within the existing water management organisations. This entire section rests on the independent interpretation of rating by the interviewer. Again, elements (4 questions) identified crucial for the phase were rated according to their level of fulfilment with a yes, no, or partially/limited. This phase links closely to the next phase as it is a prerequisite for creating feedback.

In Phase II the independent rating shows that only 28% of the interviewees saw that learning was possible and on-going within the water sector (Figure 3.4). An only slightly lower percentage of 25 rated this as not taking place at all. Almost half of all interviewees stated that some type of learning was taking place, but only with significant limitations.

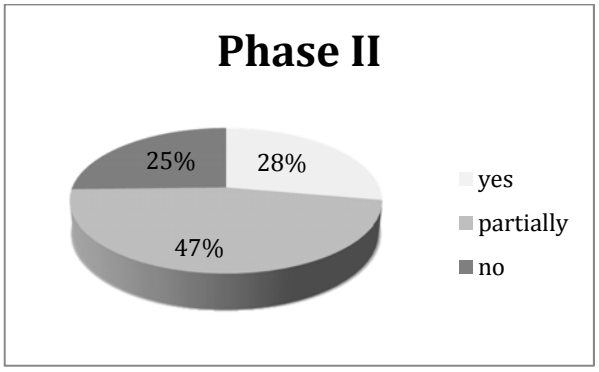


Figure 3.4 Independent rating in regard to the learning environment of the water sector

Recurring (i.e. mentioned by > 5 interviewees) themes in the comments made in this phase were:

(a) A high staff turn-over in the governmental departments on all levels has been identified as being problematic (same as in Phase I).
(b) Socio-economic data are very limited and have been attributed mainly to the national population census (which at the time of the interviews was 10 years old).
(c) Catchment Management Agencies[3] (CMAs) have often been mentioned as the example of a learning platform.
(d) Capacity building plans have often been noted as being in place, but as not working nor achieving their aims.

The highest level of agreement on fulfilment existed in regard to Question 20 in **Section B**, *viz.* user-friendly platforms for sharing information among water-related, governmental and non-governmental organizations and with the general public exists. The highest level of disagreement on fulfilment existed in regard to Question 7 in **Section B** which related to individuals and institutions (public and private) provided with incentives to improve their practices and approaches.

[3] "Catchment Management Agencies (CMAs) represent the second tier of the water resource management framework. A CMA will be established in each of the […] water management areas. Each CMA is responsible for the progressive development and broad implementation of a catchment management strategy." (de la Harpe *et al.*, undated, 8) "Catchment Management Agencies must ensure that all interested and affected stakeholders, including poor communities that have been disadvantaged and marginalized, are able to participate in the consultation processes and decisions of the CMA." (de la Harpe and Ramsden, 1998, 37)

From the responses it seems, and correctly so, that learning is a very personal experience. Many different viewpoints and reflections came to the fore in this section and individuals often referred solely to 'their part or organisation' of the water sector when answering these questions, i.e. their direct personal working environment. The topic of learning did not seem as something that should be part of the working environment, and even less so to be part of a decision-making process. The topic of learning was seemingly nothing that needed reflection in their daily working environment and decision-making. Thus it possibly challenged the interviewees and that may have been why they took time to formulate their answers. Furthermore, interviewees reflected very differently on what the appropriate platforms for learning are and could be, varying from simple websites of organisations to the complex negotiating environment of Catchment Management Agencies.

Phase III - Feedback

As elaborated upon earlier, Phase III considers whether new knowledge and learning outcomes are actually fed back into the management cycle. This links closely to the next phase as it is a prerequisite for adaptation. As in Phase II, this entire section rests on the independent rating by the interviewer. Three questions were identified being key for this phase and were rated accordingly. Phase III showed some surprising results: a significant higher number, *viz.* 37%, of the interviewees who answered saw feedbacks into the system actually taking place (Figure 3.5). Only 19% rated this with 'not at all' and 44% stated that only few feedbacks were actually taking place.

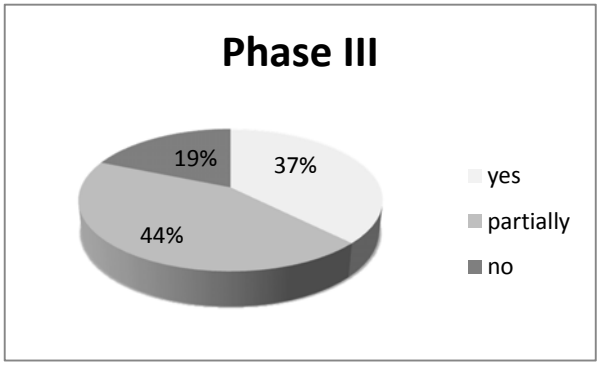


Figure 3.5 Independent rating in regard to the ability to feed back new knowledge and learning outcomes into the decision-making processes of the water sector

Recurring (i.e. mentioned by > 5 interviewees) themes in the comments made in this phase were that communication with stakeholders was, by and large, described as being 'one way', *viz.* governmental departments informing stakeholders and others. Considerable decision-making that was done was said to be based on output from computer models. At the same time the interviewees felt uncertain about the appropriate use of these models and whether, in the end, they do lead to some type of action or intervention. The feedbacks elaborated upon showed no consistency: they derived either from specific consultancies, or the outcomes of a specific research project, or sometimes from a specific organisational approach of operation.

When trying to identify the strongest and weakest elements in this phase, both were covered by the same question, i.e. Question 10 in **Section B**, *viz.* assessment results communicated to stakeholders were available in accessible form. Therefore, the authors see this as the most ambiguous of the issues amongst the interviewees and, hence, in water management. Overall, it was observed that there was only limited elaboration on the answers in this phase. The few feedback cases that were elaborated upon were, respectively, from specific personal experiences and projects. A systemic way of dealing with learning outcomes in a more general, organisational or systemic way did not become apparent from the interviews. Also, they did not show an integrated or holistic view of framing and in dealing with the issue at hand. Some feedback opportunities exist within departmental structures, but these are not fed towards society and / or other sectors.

Phase IV - Adaptation

As elaborated upon earlier, Phase IV assesses the adaptive mode of water management in South Africa, *viz.* whether there are actions of adaptation taking place which are based on any of the lessons learned and which feed back into the management cycle. This is the crucial phase in order to have an effective management approach in place, which understands on-going changes (environmental, societal, economic) as well as their consequences, which learns from outcomes, includes new knowledge and as a result optimises management performance (see Section 3.2). Phase IV shows an extremely low level of agreement among interviewees of only 13% on adaptation activities taking place within water management (Figure 3.6). The majority of interviewees, *viz.* 54%, did not see any adaptation happening while a third (33%) could see some type of adaptive interventions taking place.

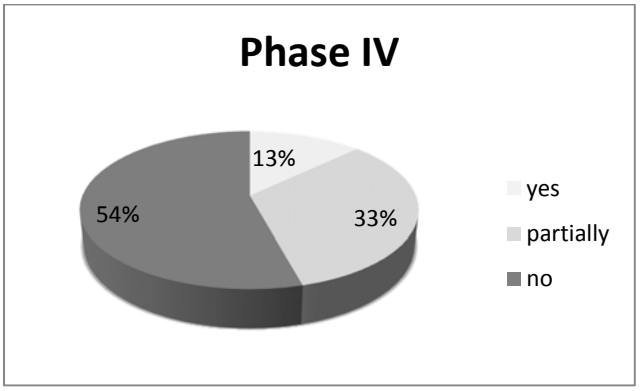


Figure 3.6 Independent rating in regard to the adaptation taking place within the overall water management approach across the South African water sector

Recurring (i.e. mentioned by > 5 interviewees) themes in the comments made in this phase were:

(a) The picture around participation and stakeholders, especially from outside of governmental structures, is very messy. Comments varied from "the layman is not useful, we [water managers] as professionals know best" (mentioned once), to several comments around "stakeholders do not participate, they are not interested", "these are non-transparent processes" and "processes are often politically hijacked".

(b) Those interviewees who did not see adaptation taking place suggested a more or less hierarchal process to be installed that ensured the initiations of activities on a higher level (even the Presidency was mentioned once), with implementation and evaluation on a lower level (regional or local).

(c) One of the key questions in this section (effective co-operation on regulatory decisions between land use planners and water managers) was often seen as not taking place (11 times) or only in a limited way (13 times). On the one hand, many of the interviewees pointed to the CMAs as the only possible place for such cooperation. On the other hand, several interviewees mentioned that the CMAs are under strong political influence.

(d) Other, or alternative, places for participatory learning and decision-making were seen to be in the Water User Associations[4] (WUAs).

[4] Water User Associations (WUAs) "are associations of individual water users that undertake water-related activities for their mutual benefit." (de la Harpe *et al.*, undated, 8) "It is a grouping of water users who wish to work together because of a common interest. The water users 'co-operate' in undertaking water-related activities at the local level for their mutual benefit." (de la Harpe and Ramsden, 1998, 39)

The strongest aspect fulfilled in this phase was the involvement of a diverse set of organisations, including those beyond the CMAs. The weakest element was, not surprisingly, the actual initiation of adaptation or adaptive management interventions.

3.5.2 The capacity narrative

As alluded to already in many sections of this paper, lack of capacity and skills was often the reasoning by the interviewees for limited implementation of any of the phases described above. When evaluating **Section D**, question 5, *viz.* Please list the 5 strongest barriers to change in the RSA[5], lack of capacity - in the sense of expertise, education, experience, knowledge, understanding, technical skills, institutional memory - was listed in the first or second place by 19 out of 33 interviewees, i.e. 58%. The most frequently mentioned other barriers were “decision makers stay in their comfort zone” (7 out of 33, i.e. 21%) and “too much change has and is taking place” (5 out of 33). Only 10 of the interviewees did not touch on any of the above mentioned barriers.

Furthermore, relatively early in the interview, i.e. in **Section B** Question 5, a general question was asked as to whether capacity was in place to fulfill the diverse mandates of water management. An overwhelming 70% of the interviewees answered that with a ‘no’, only one interviewee answered with ‘yes’. However, in the comments, the majority related the ‘no’ to Human Resources, while funding and equipment was mostly seen as not being problematic.

Upon interrogating the limited amount of capacity available within the South African water sector towards the end of the interview in **Section D** Question 7 (ca. 45 min to 1 hour later), the picture emerging was slightly skewed compared to the more general assessments beforehand: In particular the professional capacity in the country and sector was seen as fulfilled by almost half the interviewees, *viz.* 48%. The weakest dimension of capacity was seen as the compliance capacity, with 53% of the interviewees seeing this as not fulfilled at all. As can be seen in Figure 3.7 when rating the capacity based on the four dimensions identified, *viz.* political, professional, implementation and compliance capacity, only 34% of the interviewees saw hardly any capacity being available. Furthermore, more than a quarter of the interviews, *viz*. 27%, did see good capacity available in certain areas. This, compared to the results from **Section B** Question 5, shows that the strong narrative of a general lack of capacity existing in

[5] Republic of South Africa

South Africa's water sector with a specific focus on lack of capacity in governmental departments, could not be confirmed with confidence.

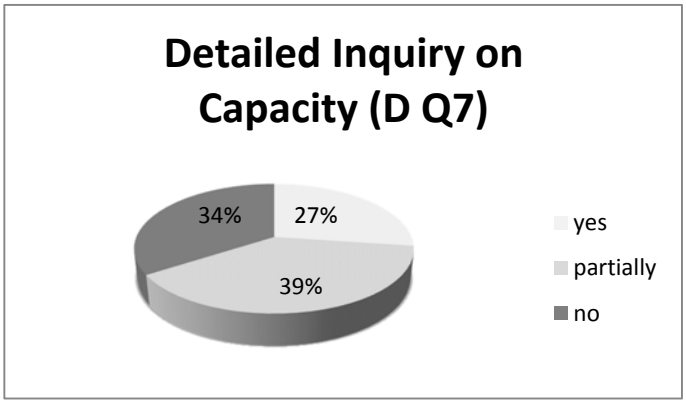


Figure 3.7 The rating of overall capacity based on the four dimensions of political, professional, implementation and compliance capacity

An additional challenge that was identified by the interviewees was around skills and leadership. These were seen as being linked closely to the capacity challenge, with 12 of the interviewees viewing skills as more important than leadership, while 13 interviewees rated skills and leadership as being equally important.

3.6 Discussion and Conclusion

The analysis shows that all four phases of the Policy-Management Cycle are distinctly mediocre to weak with a rate of fulfilment below 40%. It needs to be noted here that even Phase I (looking at integration), which should reflect well after 15 years of the 'new' National Water Act which focuses on IWRM as the management approach to be followed, and many water policies having been in place for over 10 years, still shows high levels of fragmentation and limited integration. Holistic thinking and decision-making approaches are only reflected in a few cases. Looking at the various phases of the cycle, the learning phase (Phase II) is significantly weaker than the integration phase (Phase I). Although the feedback phase (Phase III) might seem surprisingly high at a 37% fulfilment rate, this has to be seen in perspective owing to the fact that the learning outcomes are very limited and even those in place are incomplete and only partially fulfilled in that they only link certain issues or projects. Overall, learning and feedbacks are not systemic to the management approach and cycle. This also reflects in the status of communication with stakeholders etc. (governance dimension) which exists

in a systemic way, but is not effective, with real cooperation[6] lacking. The final phase of the cycle, which relates to taking adaptive action, is almost not existent.

Based on these outcomes the *status quo* of implementation in regard to an integrative and adaptive management approach in South Africa must be regarded as weak overall. It has to be assumed that the Policy-Management Cycle within government is not well established and weakens as the issues at hand (integrated learning, reflection, processing new knowledge, participatory activities and feeding back in to the system in order to enhance performance and capacity) become more demanding and complex. However, a few individual cases seem to exist; these might be the pockets of innovation that South Africa needs to learn from.

Additionally, different dimensions of capacity were discussed: The well-known narrative of a skills and capacity crisis could not be confirmed meaningfully. However, the interviewees confirmed that Human Resources are the area of greatest capacity deficiency. At least the financial situation and the availability of equipment were seen as remarkably good. What this inquiry shows is that issues need to be differentiated and broken down, otherwise, a proper understanding of the challenges at hand is not possible and any solutions designed will probably not be effective or sustainable.

On the one hand, a major challenge for South Africa's water resource management is the uneven governance landscape in regard to many of the issues discussed, *viz.* integrative and holistic thinking, law enforcement, capacity issues of different types and ineffective communication with stakeholders. On the other hand, political pressures and interference seem to exist in several cases, but they are not seen to be systemic to the governmental system. Also positive is that all phases and almost all elements seen as crucial for an effective Policy-Management Cycle exist, at least in their basic structures. This indicates that a paradigm shift from the old technological control paradigm (Stuart-Hill and Schulze, 2010) is starting to take place - at least in parts of the water management system. However, the process is extremely slow and fragmented and thus it is questionable whether it will, at all, mature further in the future towards more integrative and adaptive water management that also reflects learning aspects.

[6] Cooperation and coordination of organisations and individuals beyond their day-to-day work, i.e. normally focused on colleagues and activities within one department on one governmental level (United Nations, 2013).

Overall South Africa's water management system and sector shows a diverse set of emerging issues which need to be dealt with urgently. The Policy-Management Cycle is fragmented and not closed. Therefore, change in general, and specifically regarding climate change, cannot as yet be effectively incorporated into decision-making, intervention design and their respective implementation. This also applies to current and emerging vulnerabilities and the further degradation of the country's water resources. A starting point would be to make all policies, within and outside the water sector, 'water proof', implying an assessment as to whether water resources are required or are impacted upon (**Recommendation 1**). Furthermore, a focus should be on developing the learning phase, although only after 'investing' into the adaptation phase (**Recommendation 2**). The South African narrative of 'lack of capacity and skills' needs to be differentiated into its various dimensions. Each level will require a more detailed assessment, resulting in a tailored approach with certain tools (**Recommendation 3**), and only then can a sustainable solution to this be found. Communication with stakeholders (i.e. the governance dimension) exists in a systemic way, but is not effective, with real cooperation[7] lacking. Last but not least, fatigue is embedded in many parts of the system because of constant change taking place – new policies, change in leadership, re-organisation. It seems that a time of consolidation is urgently needed (**Recommendation 4**).

Overall, opportunities and pockets of success have been highlighted by the interviewees, besides their often negative ratings and evaluations. It seems that South Africa's water managers have not yet given up the hope of implementing their innovative and challenging water laws and policies.

3.7 Acknowledgements

This research was made possible through funding from the Water Research Commission of South Africa (WRC Project K5/1843). Warm thanks go to all those interviewees who made available some significant time within their busy daily schedules to provide insights into the realities of South Africa's water sector. Furthermore, sincerest appreciations are expressed to Prof Mark Laing, who discussed and reflected especially on the Policy-Management Cycle design.

[7] Cooperation and coordination of organisations and individuals beyond their day-to-day work, i.e. normally focused on colleagues and activities within one department on one governmental level (United Nations, 2013).

3.8 References

Agarwall, A., delos Angeles, M.S., Bhatia, R., Chéret, I., Davila-Problete, S., Falkenmark, M., Gonzalez Villarreal, F., Jonch-Clausen, T., Ait Kadi, M., Kindler, J., Rees, J., Roberts, P., Rogers, P., Solanes, M., Wright, A., 2000. Integrated Water Resources Management. TAC Background Papers by the Global Water Partnership Technical Advisory Committee, No. 4. Stockholm, Sweden.

Barnett, J., 2010. Adapting to climate change: three key challenges for research and policy – an editorial essay. WIREs Clim. Chan. 1, 314-317.

Benvie, S., 2005. A case for using adaptive platforms in the development and implementation of urban-centred adaptive management plans. Urban Ecosyst. 8, 285-311.

Berkoff, J., 2013. Viewpoint – Responding to context: Some lessons from experience in the water sector. Water Alternatives 6, 246-258.

Carriger, S., 2006a. Monitoring and evaluation indicators of IWRM strategies and plans. Technical Brief 3 of the GWP Technical Committee. Global Water Partnership, Stockholm, Sweden.

Carriger, S., 2006b. Checklist for change: Defining areas for action in an IWRM strategy or plan. Technical Brief 1 of the GWP Technical Committee. Global Water Partnership, Stockholm, Sweden.

Deason, J.P., Dickey, G.E., Kinnell, J.C., Shabman, L.A., 2010. Integrated Planning Framework for Urban River Rehabilitation. J. Water Resour. Plann. Manage. 136, 688–696.

de la Harpe, J., Ferriera, J-A., Potter, A., undated. Water Management Institutions Overview. Department of Water Affairs and Forestry, Pretoria, South Africa.

de la Harpe, J., Ramsden, P. 1998. Guide to the National Water Act. Department of Water Affairs and Forestry, Pretoria, South Africa.

Ebbesson, J., 2009. The rule of law in governance of complex socio-ecological changes. Glo. Environ. Chan. 20, 414-422.

Eriksen, S., Lind, J., 2009. Adaptation as a Political Process: Adjusting to Drought and Conflict in Kenya's Drylands. Environ. Manage. 43, 817–835.

Flick, U., von Kardorff, E., Steinke, I., 2003. Qualitative Forschung. Ein Handbuch. Rowohlt Taschenbuch Verlag, Hamburg, Germany.

Foerster, A., 2011. Developing Purposeful and Adaptive Institutions for Effective Environmental Water Governance. Water Resour. Manage. 25, 4005–4018.

Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive Governance of Social-Ecological Systems. Annu. Rev. Environ. Resour. 30, 8.1–8.33.

Grigg, N.S., 2008. Integrated water resources management: balancing views and improving practice. Water Int. 33, 279-292.

Huntjens, P., Lebel, L., Pahl-Wostl, C., Camkin, J., Schulze, R., Kranz, N., 2012. Institutional design propositions for governance of adaption to climate change in the water sector. Glo. Environ. Chan. 22, 67-81.

Holling, C.S., 2001. Understanding the complexity of economic, ecological, and social systems. Ecosyst. 4, 390–405.

Huppé, G.A., Creech, H., Knoblauch, D., 2012. The Frontiers of Networked Governance. IISD Report. Winnipeg, Canada. http://www.iisd.org/publications/ pub. aspx? pno=1576. Accessed 5 June 2013.

Inderberg, T.H., Eikeland, P.O., 2009. Limits to adaptation: analysing institutional constraints. In: Adger, W.N., Lorenzoni, I., O'Brien, K.L. (Eds.), Adaptation to Climate Change: Thresholds, Values, Governance. Cambridge University Press, Cambridge, UK, pp 433-447.

Ison, R., Collins, K., Colvin, J., Jiggins, J., Roggero, P.P., Seddaiu, G., Steyaert, P., Toderi, M., Zanolla, C., 2011. Sustainable catchment managing in a climate changing world: New integrative modalities for connecting policy makers, scientists and other stakeholders. Water Resour. Manage. 25, 3977-3992.

Iza, A., Stein, R. (Eds.), 2009. RULE – Reforming water governance. IUCN, Gland, Switzerland.

Kabat, P., 2013. Water at a crossroads. Interview. Nature Clim. Chan. 3, 11-12.

Kingsford, R.T., Biggs, H.C., Pollard, S.R., 2011. Strategic Adaptive Management in freshwater protected areas and their rivers. Biol. Conser. 144, 1194–1203.

Leach, M., Rockstrom, J., Raskin, P., Scoones, I., Stirling, A.C., Smith, A., Thompson, J., Millstone, E., Ely, A., Around, E., Folke, C., Olsson, C., 2012. Transforming innovation for sustainability. Ecol. Soc. 17, 11.

Loorbach, D., 2010. Transition management for sustainable development: A prescriptive, complexity-based governance framework. Governance: Int. J. Policy Admin. Inst. 23, 161–183.

Medema, W., McIntosh, B.S., Jeffrey, P.J., 2008. From premise to practice: a critical assessment of integrated water resources management and adaptive management approaches in the water sector. Ecol. Soc. 13, 29.

Mickwitz, P., Aix, F., Beck, S., Carss, D., Ferrand, N., Görg, C., Jensen, A., Kivimaa, P., Kuhlicke, C., Kuindersma, W., Máñez, M., Melanen, M., Monni, S., Pedersen, A.B., Reinert, H., van Bommel, S., 2009. Climate Policy Integration,

Coherence and Governance. PEER Report No 2. Partnership for European Environmental Research, Helsinki, Finland.

Never, B., 2012. Collective Learning through climate knowledge systems: the case of South Africa. Politikon: S. Afr. J. Pol. Stud. 39, 231-256.

Newig, J., Fritsch, O., 2009. Environmental Governance: Participatory, multi-level – and effective? Env. Pol. Gov. 19, 197-214.

Pahl-Wostl, C., 2006. The importance of social learning in restoring the multifunctionality of rivers and floodplains. Ecol. Soc. 11, art.10.

Pahl-Wostl, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D., Taillieu, T., 2007a. Social Learning and Water Resources Management. Ecol. Soc. 12, 5.

Pahl-Wostl, C., Jeffrey, P., Brugnach, M., Sendzimir, J., 2007b. Adaptive Water Management: How to cope with uncertainty. NeWater Policy Brief No. 4. http://www.newater.uni-osnabrueck.de/index.php?pid=1022. Accessed 12 March 2010.

Pahl-Wostl, C., 2009. A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. Glo. Environ. Chan. 9, 354-365.

Pahl-Wostl C, Jeffrey P, Isendahl N, Brugnach M (2011) Maturing the new water management paradigm: Progressing from aspiration to practice. Water Resour. Manage. 25:837–856.

Pahl-Wostl, C., Lebel, L., Knieper, C., Nikitina, E., 2012. From applying panaceas to mastering complexity: Toward adaptive water governance in river basins. Environ. Sci. Pol. 23, 24-34.

Plummer, J., Slaymaker, T., 2007. Rethinking governance in water services. Working Paper 284. Overseas Development Institute, London. http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/602.pdf. Accessed 10 October 2012.

Pollard, S., du Toit, D., 2011. Towards adaptive integrated water resources management in southern Africa: The role of self-organisation and multi-scale feedbacks for learning and responsiveness in the Letaba and Crocodile Catchments. Water Resour. Manage. 25, 3971–3976.

Rogers, P., Hall, A.W., 2003. Effective water governance. TEC Background Papers by the Global Water Partnership Technical Committee, No. 7. Elanders Novum, Sweden.

Roux, D.J., Murray, K., van Wyk, E., 2008. Learning to learn for social-ecological resilience. Balancing strategy options in public sector organisations. In: Burns,

M., Weaver, A. (Eds.), Exploring Sustainability Science – A Southern Africa Perspective. SUN Press, Stellenbosch, South Africa, pp 599-622.

Republic of South Africa (1998) National Water Act. Act. No. 36 of 1998. Government Printer, Pretoria, South Africa.

Schreiner, B., 2013. Viewpoint- Why has the South African National Act been so difficult to implement? Water alternatives 6, 239-245.

Solanes, M., Gonzalez-Villarreal, F., 1999. The Dublin Principles for water as reflected in a comparative assessment of institutional and legal arrangements for Integrated Water Resources Management. TAC Background Papers by the Global Water Partnership Technical Advisory Committee, No. 3. Stockholm, Sweden.

Someshwar, S., 2008. Adaptation as 'climate-smart' development. Dev. 51, 366-374.

Stuart-Hill, S.I., Schulze, R.E., 2010. Does South Africa's water law and policy allow for climate change adaptation? Clim. Dev. 2, 128–144.

Stuart-Hill, S.I., Herrfahrdt-Pähle, E., Pahl-Wostl, C., in preparation. Mainstreaming adaptation: Preparing decision making in the water sector. Env. Sci. Pol.

Swatuk, L.A., 2010. The state and water resources development through the lens of history: a South African case study. Water alternatives 3, 521-536.

Ténière-Buchot, P-F., 2013. Viewpoint – Happy like a clam in French Water. Water alternatives 6, 218-238.

United Nations, 2013. Water Cooperation Information Brief. International Annual UN-Water Zaragoza Conference 2012/2013. Preparing for the 2013 International Year Water Cooperation: Making it Happen! 8-10 January 2013. http://www.un.org/waterforlifedecade/water_cooperation_2013/. Accessed 15 June 2013.

Urwin, K., Jordan, A., 2008. Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance. Glo. Environ. Chan. 18, 180-191.

Wieczorek, A.J., Hekkert, M.P., 2012. Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. Sci. Publ. Pol. 39, 74–87.

Woodhill, J., 2010. Capacities for institutional innovation: A complexity perspective. IDS Bulletin 41(3), 47-59.

3.9 Annexure 1: Questionnaire

Setting the Scene

The ways we are dealing with our water resources today does not seem to be sustainable. Availability and quality problems occur throughout the country more or less independently of rainfall distribution and impacts of climate change. For the future we must find more effective, long lasting solutions to our water problems, based on the principles of efficiency, equity, and environmental sustainability. In that way today's situation – which has the potential to develop into a crisis – can provide a window of opportunity that we can use to ensure a response to a challenge rather than reinforcing the status quo. We need to put ourselves in the position to judge which management tools can treat the disease rather than the symptoms and, therefore, how we deal with constant change and constant adaptation respectively.

Date: _____
Name: _____
Q: How long have you been working in the water sector and in what position? *(Aim: pin-point Expertise)*

Section A: Enabling Environment
1-3 Policies; 4-7 Legislative Framework; 8-11 Financing and incentive structures
(Aim: define status quo in regards to implementation of the act and principles of Dublin/IWRM)

1 Water Policies accord with overall national economic policy and related sectoral policies.
2 Economic and social policies take into account water resource implications.
3 Water policies support economic efficiency, social equity and environmental sustainability in water development, management, and use.
4 Establishes secure and transferable water rights.
5 Protects public interests – including the interests of future generations for example, by ensuring water to meet environmental needs.
6 Clearly defines the responsibilities and authority of water/environmental management agencies and water and sanitation service providers.
7 Water laws are operational / enforceable.
8 Water funding strategy estimates overall investment requirements and identifies funding sources; is regularly reviewed and updated.
9 Water pricing reflects the costs of water services, operations and maintenance of infrastructure, and pollution control.
10 Subsidies for the poor, if necessary, are transparent and well-targeted.
11 In the case of public utilities, water fees are used to provide/improve services and ensure maintenance of infrastructure.
12 Others:

Section B: Institutional Roles
1-4 Organisational Frameworks
(Aim: define status quo in regards to implementation of the Act and principles of Dublin/IWRM and effectiveness of water governance)

Section B: Management Instruments
5-7 Institutional Capacity Building; 8-10 Water Resources Assessment; 11 Demand Management; 12-14 Social change instruments; 15 Conflict resolution; 16-18 Regulatory instruments; 19-21 Information management and exchange
(Aim: evaluate effectiveness of water governance)

1 Clearly defined responsibilities and the authority to carry them out: Absence of jurisdictional ambiguities and overlapping functions between organizations.
2 Coordination mechanisms between organizations responsible for sectors that impact and are impacted by water resources development, management and use.
3 Coordination mechanisms between different levels of government – from local, to province, to basin, to national.
4 No power vacuum exists into which shadow networks or lobbies may move in and corrupt the system.
5 Organizations have the capacity – in terms of human, resources, funding and equipment – to fulfil their mandates.
6 Organizations have regularly updated capacity-building plans that reflect changing needs.
7 Individuals and institutions (public and private) provided with incentives to improve their practices and approaches.
8 Regular collection and analysis of relevant physical and socio-economic data needed for decision-making at various levels.
9 Mechanisms for feeding results into decision-making and planning processes.
10 Assessment results communicated to stakeholders; available in accessible form.
11 Incentives for water use efficiency, conservation, recycling and reuse at the river basin level, at the system level, and at the individual user level.
12 Investments in empowering and involving excluded social groups. Such as women and the poor.
13 Water issues incorporated into school curricula.
14 Communication plans / campaigns attached to major water initiatives.
15 Relevant staff receives training in conflict management.
16 Regulatory instruments address water quality and quantity, are consistent and comprehensive, and cover both public and private water service providers.
17 Regulations are consistent with institutional capacity for implementation, compliance monitoring and enforcement.
18 Effective co-operation on regulatory decisions between land-use planners and water managers (for issues such as e.g. flood protection).
19 Short-term political involvements / pressures are not passed down to implementation level.
20 User-friendly platforms for sharing information among water-related, governmental and non-governmental organizations and with the general public.
21 Decision-support tools that feed information into water and development planning.

22 Participation in water-related international benchmarking, monitoring and information exchange initiatives and networks, e.g. the World Water Assessment.

Section C: Reality Check for SA
1-2 Implementation; 3-4 Transformation; 5-6 Future issues; 7-17 Relevant sectors
(Aim: assess barriers and drivers for change in SA; pin-point leadership in the SAn context)

1 Reserve determination has been implemented.
2 Awards of licenses and authorisations are fair and the process transparent.
3 Cross-sectoral activities with Department of Environment
4 Cross-sectoral activities with Department of Tourism
5 Cross-sectoral activities with Department of Finances (Treasury)
6 Cross-sectoral activities with Department of Science and Technology
7 Cross-sectoral activities with Department of Land Affairs – Spatial Planning
8 Cross-sectoral activities with Department of Agriculture
9 Cross-sectoral activities with Department of Housing
10 Cross-sectoral activities with Department of Minerals & Energy
11 Cross-sectoral activities with Department of Provincial & Local Governments
12 Cross-sectoral activities with Department of Social Development
13 Cross-sectoral activities with Department of Trade & Industry
14 Others

Section D: Other Questions
(Aim: assess barriers and drivers for change in SA; pin-point leadership in the SAn context)

1 Please assess the implementation of the NWA on a scale of 1 to 5 (***0=do not know***, 1=not at all, 5=fully implemented).
2 Please assess the implementation of the WSA on a scale of 1 to 5 (as above).
3 How far have the principles of IWRM overall been incorporated (please scale between 1 to 5 as above) in
- the regulatory frameworks of RSA, and
- day-to-day decision-making processes.

4 What are the 3 main challenges in implementing the NWA? Are there any obvious failures?
5 Please list the 5 strongest barriers to change in RSA.
6 Please list the 5 most relevant drivers to change in RSA.
7 Does leadership exist that reflects or builds capacity in the following arenas (as enhancing performance so that climate change can be mainstreamed into day-to-day decision-making processes):
(i) Political capacity (are there influential champions for the reform, can the reform produce results within a politically relevant time-scale, can opposing ministries be brought on board or isolated?).

(ii) Professional capacity (are there the professional skills needed to draft legislation, provide regulation or adjudication, provide conflict resolution etc.?).

_____

(iii) Implementation capacity (have the agencies likely to be charged with implementation the technical, financial and human resources necessary to fulfil the task?).

_____

(iv) Compliance capacity (many of the tools are designed to change water using behaviour; do users have the knowledge and ability to respond?).

_____

8 Pinpoint leadership that are currently or should be:
(i) initiating adaptive cycles,
(ii) carrying out the evaluation process, and
(iii)implementing accordingly.

9 How are 'missing' organisations / institutions / structures compensated?

10 Do only CMAs equal participation? Or are there other levels and organisations successfully involved in participation already?

11 Weigh up the importance between lacking leadership and missing skills.

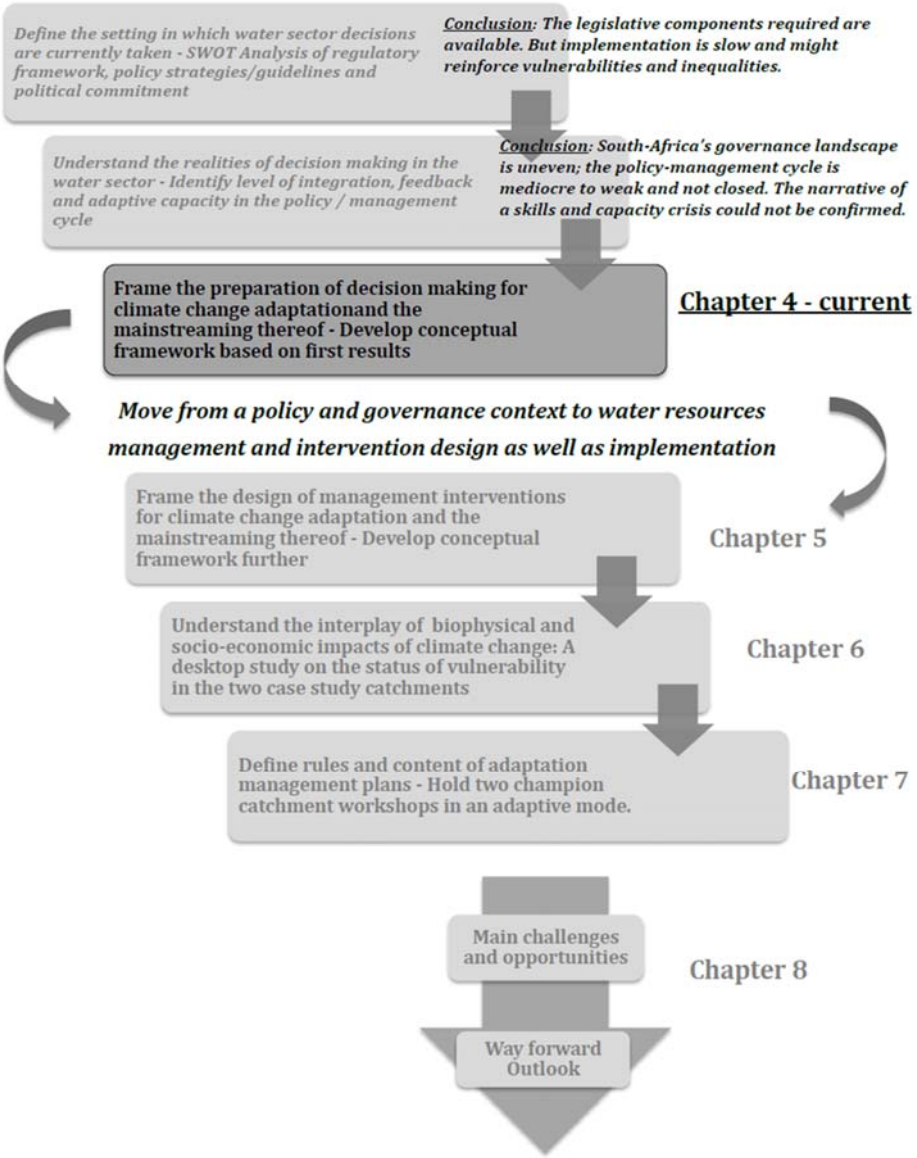
12 At what level of government / water management is the mainstreaming of CC most relevant?

4. MAINSTREAMING ADAPTATION: PREPARING DECISION MAKING IN THE WATER SECTOR

S.I. Stuart-Hill[1], E. Herrfahrdt-Pähle[2], C. Pahl-Wostl[3]

[1] Centre for Water Resources Research, School of Agriculture, Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa
[2] German Development Institute, Bonn, Germany
[3] Institute of Environmental Systems Research, University of Osnabrück, Osnabrück, Germany

At the time of submission of this thesis (March 2015) this chapter was in preparation for submission to the journal *Environmental Science and Policy*. According to the UKZN guidelines the reference list adheres to the rules of the journal.



4.1 Abstract

Climate change has been on the research agenda of many academics and donors since the early 1980s. Since the publication of the status reports of the Intergovernmental Panel on Climate Change (IPCC) the impacts of climate change in general, and on water resources in particular, have started to move into the focal point of governments and politics. As a result, the complexities in water management and water governance have increasingly been recognised over the past decades. Furthermore, our world, societies and economies are rapidly changing, creating uncertainties far beyond climate change. Especially in Africa, the focus is progressively shifting to the local context. This is the level where impacts and vulnerabilities become visible and, hence, adequate adaptation is to be designed. Thus, the core question of this paper is: What kind of framework for water governance and management is needed to address complexities and uncertainties and deal effectively with future impacts of climate change, i.e. avoiding maladaptation, and yielding potential benefits; the latter being crucial for African poverty eradication. To address such complexities the global academic and later the development aid communities have developed the concepts of Integrated Water Resources Management (IWRM). Besides infrastructural and other so-called hard measures this integrated and holistic approach focuses on participatory and soft activities, thereby offering a framework within which a range of choices for adaptation can be evaluated. As an answer to uncertainties, the discussion and development of Adaptive Management (AM) has matured and gained momentum in the past decade. Adaptive Management thinking offers ways to deal with slow as well as fast changes. The paper argues that if these two approaches are combined and focused on existing as well as emerging vulnerabilities, activities for adaptation will be framed, negotiated as well as prioritized adequately and will support sustainable development. Additionally, a governance system will emerge that offers spaces for learning as well as mainstreaming of adaptation to climate change. In brief, with climate change being one of the global change issues as to *why* we should be doing things, it is vulnerabilities that advise us as to *what* we should be doing, while IWRM and AM illustrate *how* we should be doing them.

Key words: Mainstreaming, adaptation, climate change, Adaptive Management, Integrated Water Resources Management, water governance

4.2 Introduction

One of the most significant current discussions on adapting to climate change has been fuelled by the series of IPPC Reports. They show that the impacts of climate change will, with a high probability, exacerbate problems around livelihoods and health especially in the developing world (e.g. IPCC, 2014). Agreement amongst experts also exists that the impacts of climate change and its vulnerabilities will be felt mainly through water resources. This is why this paper focuses specifically on the water sector, using water as a catalyst to create awareness and urgency to act, as well as using climate change as a catalyst to deal with change and long-term sustainable development.

As impacts of climate change on our water resources manifest themselves as vulnerabilities mostly on the local scale and, as a consequence, adaptation often has to be site-specific (e.g. Adger, 2006; Stuart-Hill and Schulze, 2010), of late greater emphasis than before is being placed by research on regional and local adaptation strategies (e.g. Ostrom, 2010). Overall, this calls for a good understanding of vulnerabilities resulting from climate change (as defined, for example, by IPCC, 2014) enabling the crucial prioritisation and implementation of adaptation actions. This is not only true for the developing world, but also for the developed world. In both cases an appropriate governance and efficient management system[1] is indispensable. However, literature identifies a lack in research on how to design adaptation options based on the interplay of climate, socio-economic characteristics and values (Storch, 2009; Barnett, 2010; Miller *et al.*, 2010; Hinkel, 2011; Hjerpe and Glaas, 2012). More so, it seems that research is lacking on how to include vulnerabilities of climate change into decision making in regard to water management and potentially mainstreaming such an approach, *viz.* moving from conceptualising governance issues to prioritising management interventions, taking decisions and implementing these. Therefore, this paper focuses on how to frame and prepare decisions on climate change adaptation in order to assure their successful implementation. The core question of this paper revolves around the kind of framework that is needed to assure sustainable development of the water sector management under projected future impacts of climate change, both in terms of governance as well as in terms of management at all levels (national to local)

[1] The terms of governance, management and systems are understood here as defined by Pahl-Wostl *et al.* (2012, 25): ”A governance system […] encompasses structural features and transient processes at both rule making and operational levels. […] Management refers to activities of analyzing and monitoring, developing and implementing measures to keep the state of a water resource within desirable bounds. The notion of governance takes into account the different actors and networks that help formulate and implement water policy.”

and at a range of spatial, temporal and administrative scales. Such a framework would need to create a decision-making environment where the design of adaptation activities is well informed, negotiations are transparent and, consequently, maladaptation becomes highly unlikely. Furthermore, adaptation must not be understood as a task solely of the governmental sector.

Projected climate change impacts and even more so resulting vulnerabilities are highly dynamic over space and time (Birkmann, 2005; Hjerpe and Glaas, 2012), as well as being uncertain in many ways. Expected impacts of climate change such as increased variability of seasonal and inter-annual climate related events (resulting, for example, in more severe droughts and floods) and increased frequency of extreme events (resulting in more frequent damages from droughts and floods) translate into increasing uncertainty about climate conditions and water availability. This exacerbates current vulnerabilities as well as leading to the emergence of 'new' vulnerabilities. At the same time the complexity of water resource management and governance is increasing (Medema and Jeffrey, 2005). In order to address these dynamics of vulnerability and complexity, adaptation needs to be framed in an integrated manner, *viz.* not only from a biophysical/environmental perspective, but taking especially its societal and economic dimensions into consideration (Koch *et al.*, 2007, TEC GWP, 2004; Reid and Vogel, 2006). This is true for all countries in any climate zone, as shown by Hjerpe and Glaas (2012) in the case of Sweden, which is located in a moderate climate, with a relatively high adaptive capacity. Here, adapting to floods in two towns is in the centre of the investigation and shows how different vulnerabilities and responses are based within socio-economic contexts. When looking at developing countries, vulnerabilities are often far more severe in the sense of threatening livelihoods, as shown by Reid and Vogel (2006) for the Muden area in KwaZulu-Natal, South Africa, as well as by Eriksen and Lind (2009) for the drylands of Kenya. Therefore, the authors are of the opinion that a vulnerability lens, guiding the design and negotiations around adaptation activities as well as their prioritisation for implementation into water management, will ensure equity and efficiency – especially in developing countries.

Furthermore, in order to address uncertainties, adaptation calls for developing adaptive capacity[2] (Folke *et al.*, 2002), as information and knowledge will need to be updated continually and fed into the governance system. As a consequence, an integrated and

[2] Adaptive capacity is understood here as defined by the IPCC (2007, 727).
"Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies."

adaptive framework will be needed to understand vulnerabilities, design adaptation activities and also evaluate them, *viz.* judging them based on their success (Barnett, 2010).

The design work of this paper is grounded on the notion of existing and emerging vulnerabilities under climate change in order to guide the preparation of decision-making as well as its implementation. This will be discussed in more detail under Section 4.3. The aim of developing an integrative and adaptive framework calls for appropriate management approaches taking spatial and temporal scales into account (*cf.* Section 4.4) for framing the approach of adaptation to climate change. Furthermore, core features needed to perform in such a management environment are identified (*cf.* Section 4.5) which, as a result, call for crucial characteristics (*cf.* Section 4.6) that are needed within the framework established (*cf.* Section 4.7) in order to successfully learn and also mainstream adaptation activities into the overall governance system. The discussion (*cf.* Section 4.8) will allude specifically to the two latter aspects.

4.3 Conceptual Background

Long-term sustainable and conscious adaptation planning (and implementation) cannot be achieved by an individual or by chance. As shown by Stuart-Hill and Schulze (2010), South Africa, for example, possesses the legal and policy frameworks needed for integration and adaptation; however, interviews with South Africa's water experts in 2009 and 2010 (Chapter 3), as well as the work by Colvin *et al.* (2008) in the Mvoti and Inkomati Catchments, in South Africa, have shown that specific organisational and individual skills are needed for successful adaptation. There is the need for a tailored way to include knowledge creation within and beyond organisations in the water sector, with as little bureaucracy as possible. This must be based on existing laws and be rooted in current policies, but needs to take into account obvious gaps and challenges in the overall governance system (Stuart-Hill and Schulze, 2010).

Therefore, the framework's aim is to support the creation of an enabling environment for the framing and preparation of decisions on climate change adaptation for the water sector. This needs to be done in a feasible way that ensures the successful implementation through management of the designed adaptation options. In the context of water management this is crucial, especially as the traditional assumption of climatic stationarity in planning and design is no longer valid under climate change (Milly *et al.*, 2008). Consequently, the framework needs to be applicable on any spatial scale –

although the catchment scale is recommended later in this Section as a cornerstone for adaptation design, prioritisation and implementation. Furthermore, the processes within the framework need to allow re-visiting as often as is deemed necessary by water managers and stakeholders. Re-visiting will become necessary when the dynamics and uncertainties surrounding climate change impacts, as alluded to earlier, alter significantly with regard to types of impacts or severity of impacts. This necessity should emerge from some type of conversations or dialogues between water managers and stakeholders. Nevertheless, participatory processes organised on a particular scale or level need to consciously inform other levels and sectors, although these do not need to be actively included in the design process itself (Pahl-Wostl, 2007). This has been proven in several cases in the southern African context (Vogel *et al.*, 2007) and in case studies across the world, for example, in Sweden, USA, Thailand, and Australia (Olsson *et al.*, 2006).

With integration and adaptation being core elements of the framework, a focus on understanding vulnerabilities, creating knowledge, dealing with change and uncertainty on an organisational as well as individual level is inevitable. This implies that the framework needs a strong adaptive element. The Resilience Theory (Folke 2006; 2010), and specifically adaptive cycles (e.g. Gunderson and Holling, 2002; Berkes *et al.*, 2003), offer repetition of actions (understood here as incorporating new information, creating new knowledge and implementing as well as evaluating action) as well as phases of repose, i.e. avoiding change or the creation of new knowledge, in order to consolidate what has been learned and including an evaluation thereof. Especially the latter phase of consolidation is important in order to gain predictability and reliability of governance and government (Termeer, 2009) in times of change as well as in periods after change (Herrfahrdt-Pähle and Pahl-Wostl, 2012). However, in order to develop a holistic and implementable framework, the concept not only has to take the overall system (systemic level) within which decisions are taken into account, but also has to take up the individual decision-maker's perspective (individual level), which includes his or her placement in an organisation (organisational level). Here we argue, that not so much an organisational viewpoint, but rather that of the individual actor and decision-maker in his or her context (Grothmann and Patt, 2005) is relevant. Only when all three levels/dimensions are incorporated is governance in its totality paid attention to. Furthermore, the interplay between elements of governance, i.e. between the legislative framework, policies, decision-makers, implementation and stakeholders, is vital for an enabling environment (Stuart-Hill and Schulze, 2010).

Special attention in our argumentation needs to be given to the concept of “change”. This refers to change within organisations as well as for individuals of that organisation. As suggested by the authors, while climate change is in itself a field of on-going new knowledge creation, so much more are the existing as well as emerging vulnerabilities as they relate strongly to socio-economic issues of society. For government and governance it means that not only is the knowledge base continually changing, but also feasible approaches to reducing vulnerabilities and other impacts of climate change. At the same time it is central to government to assure predictability in operation and enforcement, as it is essential for tenacity and planning reliability (*cf.* Herrfahrdt-Pähle and Pahl-Wostl, 2012). Thus, the framework for preparing decision-making aimed at mainstreaming adaptation presents itself as in Figure 4.1 below.

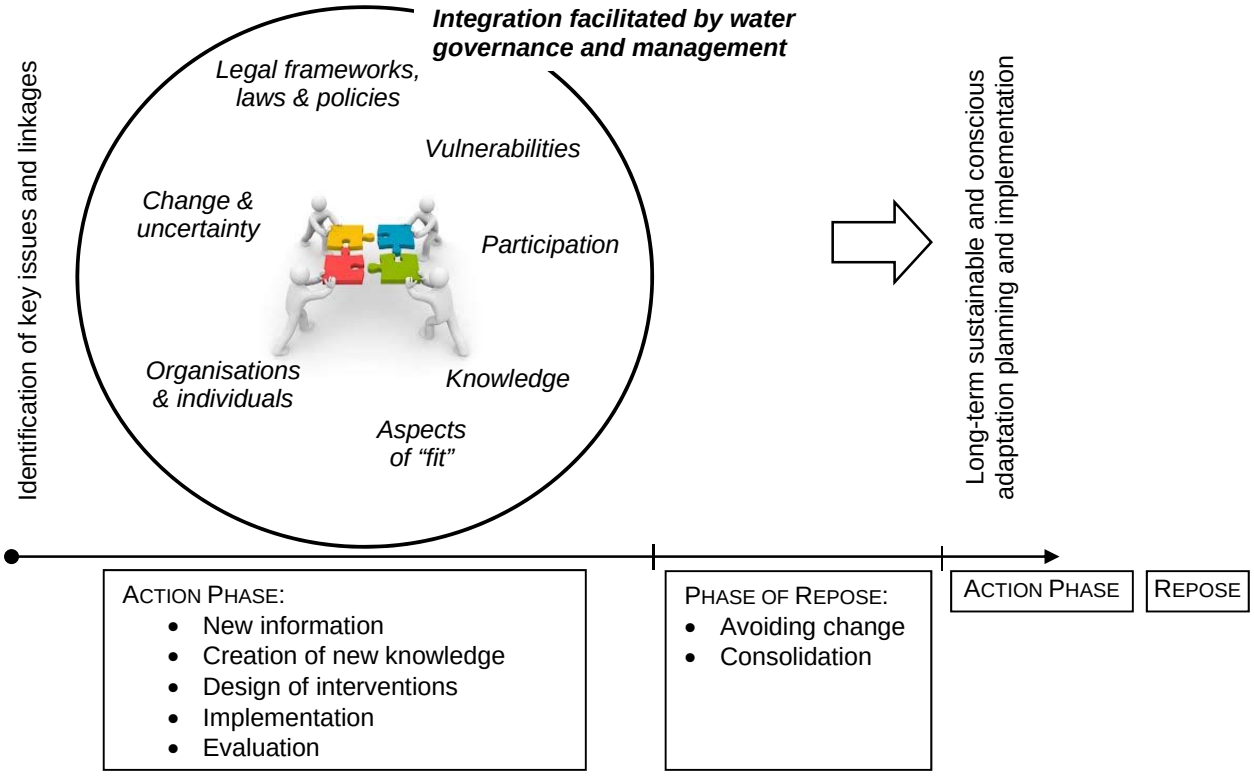


Figure 4.1 Conceptual elements of mainstreaming adaptation into decision-making of the water sector

Another crucial aspect for the framework is that of “fit” between social and ecological systems (Young, 2002). Young (2002) identifies the concept of fit as a means of increasing the effectiveness of natural resource management by assuring closeness of

ecological system and social system properties, the latter referring especially to governing institutions, in order to deal with undesirable environmental change. “Fit” can be categorised in various ways, depending on the properties of both the resource and the institutional arrangements chosen for the analysis, for example in a spatial or functional sense (Cash *et al.,* 2006; Cumming *et al.,* 2006; Folke *et al.,* 2007). **Spatial fit** refers to the matching of resource boundaries and institutional regimes governing them (Young, 2002). A lack of spatial fit, e.g. a mismatch of jurisdictional and hydrological boundaries, is associated with poor resource management results, since institutions which cover only part of the resource may ignore or have negative external effects (Moss, 2007). A divergence of the geographical area of a natural resource, and the area covered by the institutions governing this resource, serves as an example. The result of such a divergence in the water sector may be the over-use and pollution of water resources, resulting in the loss of a social system’s adaptive capacity and of an ecological system’s resilience.

Functional fit relates to the congruence of resource use mechanisms or institutional attributes, on the one hand, and ecosystem functionality, i.e. the ecosystem properties or functions addressed through them, on the other (Cumming *et al.,* 2006; Ekstrom and Young, 2009). A functional mismatch may, for example, occur if water pricing mechanisms are so designed that they result in a rate of groundwater use higher than the rate of aquifer recharge and thus the depletion of the aquifer. The requirements of the various dimensions of fit may be consistent with each other if, for example, the institutional arrangement provides for the monitoring of water availability in a catchment (spatial fit) and allows for water use rights to be adjusted on the same scale, i.e. in the catchment, according to seasonal availability (functional fit). However, the requirements associated with the dimensions of fit often differ and sometimes contradict each other as scales of negotiations, regulations and decisions do not necessarily fit and hence, discrepancies exist (Herrfahrdt-Pähle, 2010; Herrfahrdt-Pähle, 2014). Scales of fit most probably will differ depending on the issue that needs to be dealt with. In such cases the appropriate properties or dimensions for which fit should be achieved are often difficult to determine, and trade-offs are inevitable. Therefore, the “most appropriate adaptation responses will often be multi-level responses” due to the diversity of impacts of climate change (Adger, 2001, 924). However, most often water governance and management seem to give preference to spatial fit and thus promote the catchment as the backbone of integrated water management (Moss, 2007). To finally negotiate and take decisions on adaptation and management interventions the catchment

does seem to the most appropriate space as this is where the visions of policy meet local needs and potential limitations for implementation are revealed.

Especially when policies and the organisational format and way of operation support a catchment based dialogue, as it is in the South African case by IWRM being the legally binding management approach, the catchment is a space that lends itself strongly to create and benefit from social learning processes. New partners and networks will develop new knowledge and will have to "integrate different, but equally valid, approaches to knowledge rather than to start with a one-sided perspective and to add insights from the other perspective at the margin." (Young, 2006, p. 9) This offers the possibility of a variety of social learning processes (Mostert *et al.*, 2007, Huntjens *et al.*, 2012; Hjerpe and Glaas, 2012; Pahl-Wostl *et al.*, 2011). Additionally, in this learning space science will play an important role in assisting with knowledge creation and guiding the making of sense (Roux *et al.*, 2006). Several workshops in the Mgeni and Berg catchments of South Africa in the years 2011, 2012 and 2013 have shown this to be true. Furthermore, there is the danger of experts and managers making assumptions based on what they know, but when they 'dig deeper' and reflect in a participatory and learning-oriented way, integrated and informed adaptation design is enabled (Stuart-Hill and Schulze, 2011).

4.4 Integrated Water Resources Management (IWRM) and Adaptive Management (AM): Combining Water Management and Governance Approaches for Adaptation

The complexities in water management and water governance have increased significantly over the past decades (Gleick 2003; Pahl-Wostl, 2009; Pahl-Wostl *et al.*, 2010). This has also led to a greater emphasis on water governance because the technological control paradigm is experiencing its limits with regard to costs of social and ecological damage as well as ensuring access to water of an appropriate quality over space and time by the human and natural system (Milly *et al.*, 2008; Huitema and Meijerink, 2010). Furthermore, recent discussion on global water governance and management has highlighted the challenge of decision makers who have to deal with impacts of a global scale that translate into a local context and finally impact on the local level (Barnett, 2010) and on individual livelihood and living standards, through for example water services (Schulze, 2008). With Integrated Water Resources Management, IWRM (e.g. GWP, 2000 and updates), both the academic community globally and subsequently the development cooperation / assistance community have

developed an integrated and holistic approach that focuses on participatory and "soft" in addition to infrastructural and "hard" issues (Gleick, 2003). As alluded to earlier, existing and emerging vulnerabilities should guide decision-making and these, therefore, need to be known when designing adaptation activities/strategies and especially when and prioritising these for implementation. To finally design feasible and successful management interventions vulnerabilities furthermore need to be understood within a context (i.e. historically as well as current, biophysical and socio-economic). This is where IWRM as a management approach offers an understanding of the complexities between society, the environment and economic activities (Colvin *et al.*, 2008; Grigg, 2010). Hence, within IWRM a range of choices for management interventions can be evaluated by a range of actors and decision-makers jointly based on the long-term vision of sustainable water management. However, the latter might prove to be a weakness in times of change and uncertainty where short- to mid-term interventions, their evaluation and a more iterative and partially explorative management approach is needed.

The world, its societies as well as its economies are changing rapidly, creating uncertainties (Ostrom, 2010) far beyond those of climate change. However, climate change does provide an opportunity to learn proactively how to adapt to slow ("push") and fast ("pulse") changes, to mitigate negative impacts and to simultaneously harvest the benefits from such change (Adger, 2006; Gallopin, 2006). This is why adaptive water management, AM (e.g. Adger, 2001 and 2009; Roux *et al.*, 2006; Pahl-Wostl, 2007 and 2008), has increasingly been discussed, developed and explored in diverse cases around the world. Adaptive management is an attempt to deal with these uncertainties and enable (water) managers to act despite incomplete information, opening the opportunity to "*accelerate the rate at which environmental decision makers learn from experience*" (McLain and Lee, 1996, 438). One definition of adaptive management is connected to seeing policy as a set of experiments. Hence, it requires open and flexible institutions and a multi-level governance system as the process of learning takes place when these experiments are undertaken. It allows for learning and thus increases adaptive capacity without at the same time foreclosing future development options (Folke *et al.*, 2002). Thus, AM gives justice to the dynamics not only of the climate itself, but especially also to socio-economic changes and feedback loops between the two. However, AM also displays a potential weakness: The main strategic vision which needs a long-term foresight and commitment, similar to a common ground for negotiations, might be lost in an experimental and, therefore, a more short- or mid-term sighted, and the long-term approach might be the way to go.

Hence, IWRM when combined with a stronger focus on AM could see the weaknesses of the one being complemented by the strength of the other. Both would emphasise the holistic approach and responsiveness of the system needed (Muller, 2007), thus promising a governance system that can deal better with change and uncertainty, as well as facilitating on-going learning and negotiations within and beyond the water sector. Furthermore, this combination opens the opportunity to make use of the flexibility offered by most water regulations, and also facilitates the opportunity to overcome challenges of implementation, as they often exist in the developing world (Schulze, 2007). This could mark the entry into a progressive water management era: The framework and its adaptive practices would allow to frame, design and negotiate adaptation activities adequately and, therefore, could create momentum to proactively face negative impacts of climate change and benefit from others, thereby reducing vulnerability specifically in the poverty stricken communities of our global society.

However, in order to implement integrative understanding, as well as to negotiate prioritisation of adaptation activities / strategies and adaptive implementation and the management thereof, certain performance characteristics need to exist within government as well as governance.

4.5 Characteristics Needed to Perform Under IWRM and AM

The application of the framework outlined above will require certain characteristics in order to perform in an environment of sequential change and periods of consolidation as well as evaluation (*viz.* feedbacks and adaptation). These characteristics are coordination and cooperation in order to deal with complexities within and beyond the water sector, and flexibility and responsiveness in order to deal with uncertainties and change.

Firstly, existing but especially emerging complexities under climate change have to be understood in an integrated, i.e. holistic manner, in order to design appropriate adaptation options. The dynamics that are displayed through the interplay of biophysical and socio-economic features of the spatial unit (e.g. nation, catchment, sub-catchment, municipality) under scrutiny can only be understood sufficiently when a diversity of knowledge and views are expressed and brought together (e.g. Koch *et al.*, 2007). Additionally, designing adaptation options beyond just communicating risk is imperative (Grothmann and Patt, 2005). Essential mechanisms are, therefore, not only

communication, but go further and achieve coordination and cooperation (Rogers *et al.*, 2000; TEC GWP, 2004, Folke *et al.*, 2005; Olsson *et al.*, 2006; Vogel *et al.*, 2007). A lack of coordination in the water management of the Inkomati Catchment in South Africa, for example, has shown how this may hinder IWRM implementation and effective overall governance (Colvin *et al.*, 2008). Cooperation is understood here as connecting across levels and scales resulting in collective action towards a common goal or even in contractual arrangements on finance management, joint management strategies, joint monitoring, mediation, and dispute resolution (UN, 2013). Cooperation results in connections that should be "linking different networks and creating opportunities for new interactions [as these] are important when dealing with uncertainty and change" (Olsson *et al.*, 2006, 13). As demonstrated by Sherwill *et al.* (2007) in the Sabie and Sand Catchments of South Africa, this is also the key to overcoming past inequalities and gaining a level field for negotiations with regard to power and confidence. The transparency and organisation of those connections as well as their outcomes (i.e. designed adaptation options, evaluations, implementing interventions) need to be well coordinated. Thus, for a holistic approach that can even deal with trade-offs when prioritising adaptation options and implementing these, *coordination and cooperation* within the water sector as well as beyond is crucial.

Secondly, uncertainties which are increasingly emerging in the context of climate change require a revisit of governance structures regarding their flexibility and responsiveness. Flexibility is needed to enable continual adaptation as and when social, ecological or economic parameters change over time (Olsson *et al.*, 2006). Adaptive water governance requires flexible institutions (i.e. rules and norms), which offer mechanisms that provide for the adjustment of management procedures and governance structures (Pahl-Wostl, 2007). Institutions should simultaneously provide planning security and leeway for adapting to unforeseen events. For example, several provisions of the South African National Water Act include time-bound regulations. Thus the National Water Resource Strategy is subject to reviews every five years. Likewise, water licences should be reviewed every five years and may not be granted for longer than 40 years. This allows for re-allocation of water resources.

In comparison to flexibility, responsiveness to contextual changes goes one step further since it involves the direction of change (Pollard and du Toit, 2011). Responsiveness (both of the system and individual actors) is thus not only about recognising changes in the water system (for instance, decreasing water availability or increasing water pollution), but also about reacting to them with timely, adequate measures (Herrfahrdt-

Pähle and Stuart-Hill, 2010). Pollard and du Toit (2011) have shown the relevance of this in the Letaba and Crocodile Catchments of South Africa. Again, contextualising the IWRM agenda and breaking it down to a local level shows how critical responding and being flexible are for an integrated and adaptive approach to water governance and management. Past experience as well as current and future changes in the social-ecological system (such as increasingly frequent droughts and floods as well as increasing vulnerabilities) need to be monitored and taken into account in the decision making process. In addition, the long-term effects of present interventions need to be anticipated (e.g. by climate proofing) and monitored during implementation in order to be able to adjust measures that have unintended negative effects. Summing up, in an environment of uncertainty and change *flexibility and responsiveness* are needed to deal with new information and creating appropriate knowledge to inform 'better' decision making and adjusting management interventions as well as governance approaches.

Based on the discussion above, the design of actual adaptation interventions within the arena of water governance presents itself as in Figure 4.2 below.

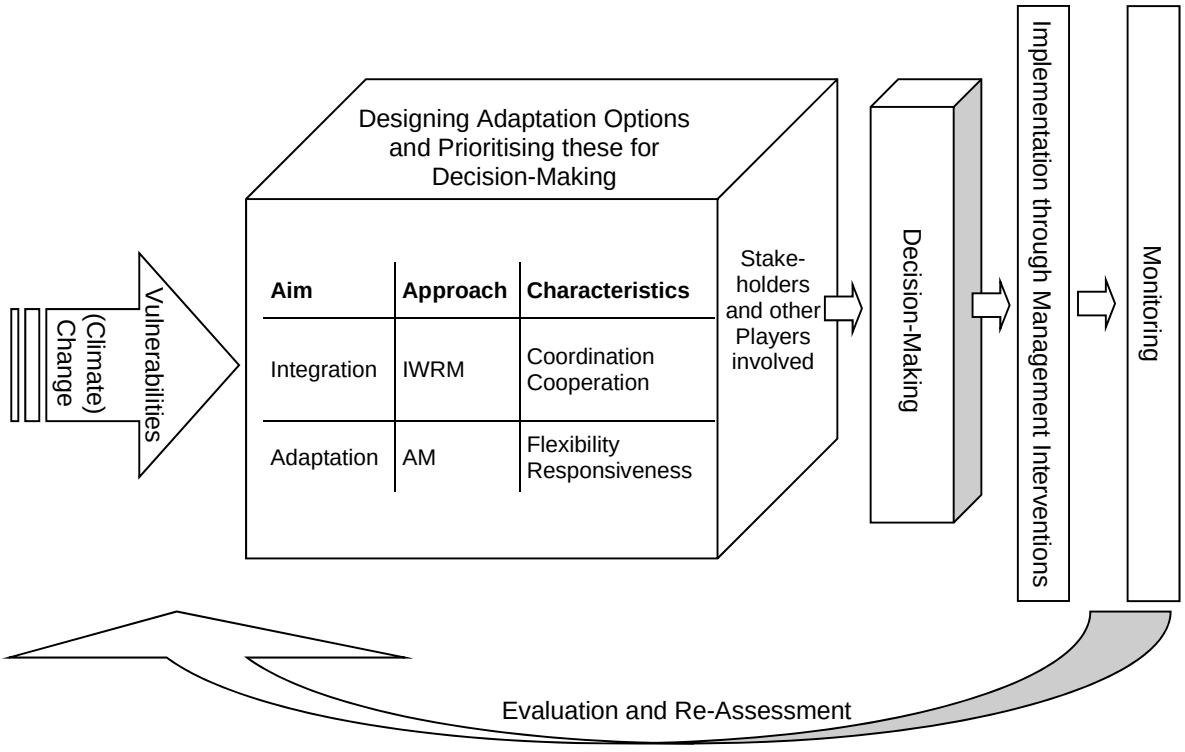


Figure 4.2 Conceptualising water governance and management interventions for adapting to climate change

4.6 Maintaining Success

Both IWRM and AM have been criticised for neglecting the governance perspective and the political dimension of natural resource management. However, numerous studies underline the relevance of factors such as power structures or incentives for the successful implementation of policies (Young, 2006; Wallis and Ison, 2011). Experience shows that a conceptual framework such as the one above could even be supported by existing legislation, but that implementation and accompanying performance does not necessarily unfold (e.g. Stuart-Hill and Schulze, 2010). Therefore, "applying" those characteristics identified will requisite certain catalysts on an individual as well as an organisational level.

As indicated earlier, the climate change arena and its emerging vulnerabilities play out very diversely even within close local proximities. Bringing knowledge together from different spheres in order to design and prioritise adaptation (*viz.* coordination and cooperation) is the first step of the decision-making process, i.e. the preparation thereof. In order to evaluate and optimise management interventions *reflection* is needed (the second step). Only when individuals reflect on their values, frames and knowledge on their own, as well as while negotiating management interventions, will adaptation take place on a broader scale than just incrementally improving established management practice (Pahl-Wostl, 2009). Only then can flexibility and responsiveness be directed towards adapting effectively on different temporal and spatial scales, avoiding maladaptation and consciously dealing with trade-offs of certain decisions or/and interventions.

Additionally, adaptation to climate change is not a once-off activity, but is on-going and is a means of dealing with new information, creating new knowledge, and adjusting decisions taken if so indicated by evaluation, e.g. in the case of maladaption. For individuals who finally take the decision this means operating in an environment of severe and often needed change. Such change might only be the improvement of routines, but might also go as far as questioning policies and law (i.e. transforming, see Pahl-Wostl, 2009). Especially transformation will pose a threat to all those who are formally mandated to make water management decisions, as change is often experienced as being painful. Resistance may be built up as water managers, i.e. governmental officials in their day-to-day working environment, could feel insecure despite understanding the need for change and adjustments (TEC GWP, 2004). Hence,

guidance and *leadership* are needed to create a sense of stability and certainty by which stress can be avoided (Muller, 2007; Taylor, 2010). Leadership differs from pure management by including facilitating processes, engaging with individuals and creating the motivation for long-term impacts within the leaders' organisation as well as outside of it in the water sector (Termeer, 2009). Leaders "see business challenges as opportunities for growth and learning on the part of both individuals and the organisation" (Rooke and Torbert, 2005, 76). Furthermore, leadership may be displayed by individuals as well as by teams (Taylor *et al.*, 2011). Several case studies, not only in the developing world, have underlined the importance of such leadership. For example, Biggs *et al.* (2008) and Pollard *et al.* (2011) have shown this in the success of the Kruger National Park Rivers Research Initiative, South Africa; Taylor *et al.* (2011) have shown this in six cases for the Australian water sector, as well as other case studies done across the world by Olsson *et al.* (2006). Sherwill *et al.* (2007) have shown that a lack of leadership in participatory processes even excludes groupings from decision-making processes. Thus, leadership in the sense of enabling knowledge creation, learning and especially communication will be a requisite to deal not only with change, but also when negotiating adaptation options and implementing these.

Resultantly, *reflection* and *leadership* are needed by individuals as well as by organisations for the actual management interventions in order to achieve feasible and successful adaptation in the long-term. With this we conclude the framework design and can display the issues discussed above as in Figure 4.3.

Aim	**Approach**	**Characteristic**	**Requisite**
Integration	IWRM	Coordination Cooperation	Leadership
Adaptation	AM	Flexibility Responsiveness	Reflection

Figure 4.3 Moving from the preparation of decision making to preparing management interventions

4.7 Deriving a Framework for Adapting to Climate Change

Our point of departure for this paper has been the projected impacts of climate change that translate into a very diverse set of vulnerabilities in a local context. These may be as drastic as threatening lives and livelihoods of people, creating economic crisis or resulting in collapses of governance systems. Understanding these vulnerabilities in an integrated manner and designing appropriate adaptation options is therefore imperative. However, we must be aware of the uncertainties and constant change associated with climate change as well as socio-economic features of communities.

We can summarise:

- Global change and climate change respectively are ***why*** we should do things
- Vulnerabilities identify ***what*** we should be doing or prioritising
- IWRM and AM inform us as to ***how*** we should approach the design of adaptation options.

Additionally, characteristics have been derived, based on IWRM and AM in order to perform in an environment of sequential change and periods of consolidation as well as evaluation. These include:

- Dealing with uncertainty in order to increase resilience, which is expressed through *flexibility*
- Enabling change and adjustment, which is expressed through *responsiveness*
- Establishing a discourse amongst governmental departments and divisions within as well as beyond the water sector, which is expressed through *coordination*
- Connecting across levels and scales, which is expressed through *cooperation*

Furthermore, three core characteristics of the framework have been derived in order to move towards decision-making:

- While designing and prioritising adaptation options one needs to include all stakeholders, leadership is needed for taking the decision of the final management intervention, and this answers the question as to ***who*** should be implementing.
- Secondly, the catchment is identified as a potential space, as to ***where*** the discourse should take place (including other spatial scales is advisable!).

- Thirdly, reflection of individuals and organisations is indispensable in order to evaluate and therefore optimise and re-visit decisions taken, and this answers the question on ***how*** we should take decisions and perform management.

4.8 Conclusions

It has been shown that not only is the preparation of adaptation options a complex process, but even that moving from design to decision making and final implementation are not easy tasks and actually call for certain pre-conditions (here called characteristics and requisites). Consequently, just because stakeholders or government know of climate change impacts, it cannot be expected that management interventions will automatically be implemented. However, the suggested framework offers two additional benefits that emerge as interesting spaces: mainstreaming climate change and social learning processes; see Figure 4.4.

The authors' understanding of mainstreaming climate change needs to be differentiated into two aspects: that of governance and that of management. In the context of governance it means creating pre-conditions and offering the required options to access choices for action and adaptation respectively. In the context of actual management, and therefore decision making, mainstreaming is rather seen as being a process which aims at designing, prioritising and implementing management interventions. Basically mainstreaming climate change calls for exceeding existing planning processes and breaking through the usual pattern of thinking. Such a space opens when leadership and flexibility / responsiveness meet. However, this needs further investigation as this would call for a highly adaptive and potentially even an iterative process that continually creates and mainstreams new knowledge.

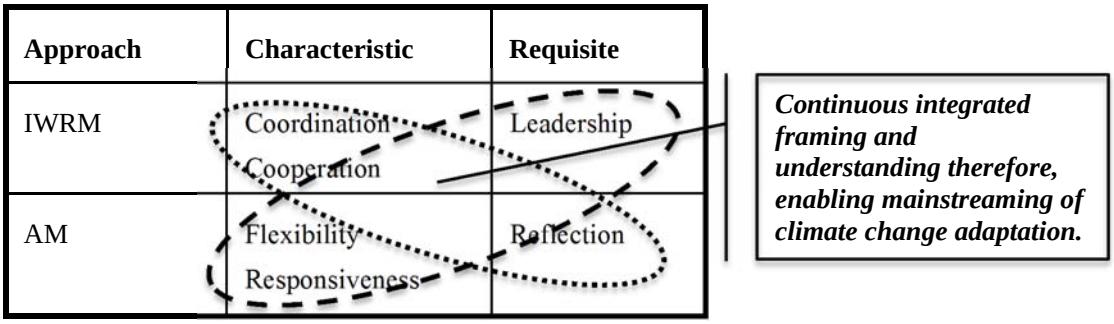


Figure 4.4 Window of opportunity for mainstreaming climate change adaptation

Another space that is emerging is when cooperation / coordination meet reflection – especially when this happens "out the box" (*viz.* with new partners and networks). Any spatial scale or level of interaction offers this unique and very valuable space in which a more integrated framing of the impacts of climate change and resulting vulnerabilities can take place. However, in order to design and implement real management interventions, further investigations will be needed on aspects of the science-policy interface as well as the science-society interface.

4.9 Acknowledgements

The authors wish to thank the National Research Foundation of South Africa for its financial support in this research, especially since it assisted in discussing and developing the framework which had been drafted with colleagues of the German Development Institute (Bonn, Germany). We additionally acknowledge the financial support of the Water Research Commission of South Africa in this research.

4.10 References

Adger, W.N., 2001. Scales of Governance and Environmental Justice for Adaptation and Mitigation of Climate Change. J. Intern. Dev. 13, 921–931.

Adger, W.N., 2006. Vulnerability. Glo. Env. Chan. 16: 268–281.

Adger, W.N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D.R., Naess, L.O., Wolf, J., Wreford, A., 2009. Are there social limits to adaptation to climate change? Clim. Chan. 93: 335–354.

Barnett, J., 2010. Adapting to climate change: three key challenges for research and policy – an editorial essay. WIREs Clim. Chan. 1: 314-317.

Berkes, F., Colding, J., Folke, C. (Eds.), 2003. Navigating social-ecological systems: Building resilience for complexity and change, Cambridge University Press, Cambridge, UK.

Biggs, H.C., Breen, C.M., Palmer, C.G., 2008. Engaging a Window of Opportunity: Synchronicity between a Regional River Conservation Initiative and Broader Water Law Reform in South Africa. Intern. J. Water Resour. Dev. 24(3): 329-343.

Birkmann, J. (Ed.), 2005. Danger Need Not Spell Disaster – But How Vulnerable Are We? Research Brief 1, United Nations University, Tokyo.

Cash, D.W., Adger, N.W., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, L., Young, O., 2006. Scale and cross-scale dynamics: Governance and information in a multilevel world. Ecol. Soc. 11: Art. 8.

Colvin, J., Ballim, F., Chimbuya, S., Everard, M., Goss, J., Klarenberg, G., Ndlovu S., Ncala, D., Weston, D., 2008. Building capacity for co-operative governance as a basis for integrated water resource managing in the Inkomati and Mvoti catchments, South Africa. Water SA 34(6): 681-690.

Cumming, G.S., Cumming, D.H.M., Redman, C.L., 2006. Scale mismatches in social-ecological systems: Causes, consequences, and solutions. Ecol. Soc. 11: Art. 14.

Ekstrom, J.A., Young, O.R., 2009. Evaluating functional fit between a set of institutions and an ecosystem. Ecol. Soc. 14(2): Art. 16.

Eriksen, S., Lind, J., 2009. Adaptation as a Political Process: Adjusting to Drought and Conflict in Kenya's Drylands. Environ. Manage. 43: 817-835.

Folke, C., 2006. Resilience: The emergence of a perspective for social–ecological systems analyses. Glob. Environ. Chan. 16: 253–267.

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C.S., Walker, B., Bengtsson, J., Berkes, F., Colding, J., Danell, K., Falkenmark, M., Gordon, L., Kaspersson, R., Kautsky, N., Kinzig, A., Levin, S.A., Maler, K.-G., Moberg, F., Ohlsson, L., Olsson, P., Ostrom, E., Reid, W., Rockstrom, J., Savenije, H., Svedin, U., 2002. Resilience and sustainable development: building adaptive capacity in a world of transformations. Report for the Swedish Environmental Advisory Council 2002:1, Ministry of the Environment, Stockholm, Sweden.

Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive Governance of Social-Ecological Systems. Annu. Rev. Environ. Resour. 30: 8.1–8.33.

Folke, C., Pritchard, L., Berkes, F., Colding, J., Svedin, U., 2007. The problem of fit between ecosystem and institutions: Ten years later. Ecol. Soc. 121: Art. 30.

Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T., Rockström, J., 2010. Resilience thinking: Integrating resilience, adaptability and transformability. Ecol. Soc. 15: Art. 4.

Gallopín, G.C., 2006. Linkages between Vulnerability, Resilience, and Adaptive Capacity. Glo. Environ. Chan. 16: 293–303.

Gleick, P.H., 2003. Global Freshwater Resources: Soft-Path Solutions for the 21st Century. Sci. 302: 1524-1528.

Grigg, N.S., 2010. Integrated water resources management: balancing views and improving practice. Water Internat. 33(3): 279-292.

Grothmann, T., Patt, A., 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. Glo. Environ. Chan. 15: 199-213.

Gunderson, L.H., Holling, C.S. (Eds.), 2002. Panarchy: Understanding transformations in human and natural Systems. Island Press, Washington DC, USA.

Herrfahrdt-Pähle, E., 2014. Applying the concept of fit to water governance reforms in South Africa. Ecol. Soc. 19(1): 25, Special Feature: Nudging Evolution? Critical Exploration of the Potential and Limitations of the Concept of Institutional Fit for the Study and Adaptive Management of Social-Ecological Systems.

Herrfahrdt-Pähle, E., 2010. South African water governance between administrative and hydrological boundaries. Clim. Dev. 2(2): 11-127.

Herrfahrdt-Pähle, E., Pahl-Wostl, C., 2012. Continuity and change in social-ecological systems: the role of institutional resilience. Ecol. Soc. 17(2): Art. 8.

Herrfahrdt-Pähle, E., Stuart-Hill, S.I., 2010. African developments: Adapting to climate change - a governance challenge. Briefing Paper 16/2010, German Development Institute, Bonn, Germany.

Hinkel, J., 2011. Indicators of vulnerability and adaptive capacity: Towards a clarification of the science–policy interface. Glo. Environ. Chan. 21: 198–208.

Hjerpe, M., Glaas, E., 2012. Evolving local climate adaptation strategies: incorporating influences of socio–economic stress. Mitig. Adapt. Strat. Glo. Chan. 17(5): 471-486.

Huitema, D., Meijerink, S., 2010. Realizing water transitions: the role of policy entrepreneurs in water policy change. Ecol. Soc. 15(2): Art. 26.

Huntjes, P., Lebel, L., Pahl-Wostl, C., Camkin, J., Schulze, R., Kranz, N., 2012. Institutional design propositions for the governance of adaptation to climate change in the water sector. Glo. Environ. Chan. 22: 67–81.

IPCC, 2014. Climate Change 2014. Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, USA.

Koch, I.C., Vogel, C., Patel, Z., 2007. Institutional dynamics and climate change adaptation in South Africa. Mitig. Adapt. Strat. Glo. Chan. 12: 1323-1339.

McLain, R.J., Lee, R.G., 1996. Adaptive management: promises and pitfalls. Environ. Manage. 20: 437–448.

Medema, W., Jeffrey, P., 2005. IWRM and adaptive management: Synergy or conflict? NeWater Report Series No. 7, University of Osnabrück, available at: http://www.tias.uni-osnabrueck.de/newater/20060927_02_review_iwrm_concepts.pdf (accessed 10 July 2009).

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., Van der Leeuw, S., Rockström, J., Hinkel, J., Downing, T., Folke, C., Nelson, D., 2010. Resilience and vulnerability: complementary or conflicting concepts? Ecol. Soc. 15(3): Art. 11.

Milly, P.C.D., Betancourt, J., Falkenmark, M., Hirsch, R.M., Kundzewicz, Z.W., Lettenmaier, D.P., Stouffer, R.J., 2008. Stationary is dead: whither water management? Sci. 319: 573-574.

Moss, T., 2007. Solving problems of 'fit' at the expense of problems of 'interplay'? The spatial reorganisation of water management following the EU Water Framework Directive. In Mollinga, P.P., Dixit, A., Athukorala, K. (Eds.), Integrated Water Resources Management: Global theory, emerging practice and local needs, Sage Publications, New Delhi/Thousand Oaks/London, pp. 64-108.

Mostert, E., Pahl-Wostl, C., Rees, Y., Searle, B., Tàbara, D., Tippett, J., 2007. Social learning in European river-basin management: barriers and fostering mechanisms from 10 river basins. Ecol. Soc. 12(1): Art. 19.

Muller, M. (lead author), 2007. Climate Change Adaptation and Integrated Water Resource Management – An Initial Overview. Policy Brief 5, Technical Committee (TEC) GWP, Sweden.

Olsson, P., Gunderson L.H., Carpenter, S.R., Ryan, P., Lebel, L., Folke, C. and Holling, C.S. (2006), "Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems", Ecology and Society, Vol. 11 No. 1, Art. 18.

Ostrom, E., 2010. Polycentric systems for coping with collective action and global environmental change. Global Environmental Change 20: 550-557.

Pahl-Wostl, C., 2007. Transitions Towards Adaptive Management of Water facing Climate and Global Change. Water Resource Management 21: 49 – 62.

Pahl-Wostl, C., 2008. Requirements for Adaptive Water Management. In Pahl-Wostl, C., Kabat, P., Möltgen, J. (Eds.), Adaptive and Integrated Water Management. Coping with Complexity and Uncertainty, Springer Verlag, Heidelberg, Germany, pp. 1-22.

Pahl-Wostl, C., 2009. A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. Global Environmental Change 9(3): 354-365.

Pahl-Wostl, C., Holtz, G., Kastens, B., Knieper, C., 2010. Analyzing complex water governance regimes: the Management and Transition Framework. Environmental Science and Policy 13: 571–581.

Pahl-Wostl, C., Jeffrey, P., Isendahl, N., Brugnach, M., 2011. Maturing the New Water Management Paradigm: Progressing from Aspiration to Practice. Water Resources Management 25: 837–856.

Pahl-Wostl, C., Lebel, L., Knieper, C., Nikitina, E., 2012. From applying panaceas to mastering complexity: Toward adaptive water governance in river basins. Environmental Science and Policy 23: 24–34.

Pollard, S., du Toit, D., 2011. Towards Adaptive Integrated Water Resources Management in Southern Africa: The Role of Self-organisation and Multi-scale Feedbacks for Learning and Responsiveness in the Letaba and Crocodile Catchments. Water Resources Management 25: 3971–3976.

Reid, P., Vogel, C., 2006. Living and responding to multiple stressors in South Africa—Glimpses from KwaZulu-Natal. Global Environmental Change 16: 195–206.

Rogers, K., Roux, D., Biggs, H., 2000. Challenges for catchment management agencies: Lessons from bureaucracies, business and resource management. Water SA 26(4): 505-511.

Rooke, D., Torbert, W.R., 2005. Transformations of Leadership. Harvard Business Review, April 2005, pp. 66-76. Harvard Business Publishing, Watertown, USA.

Roux, D.J., Rogers, K.H., Biggs, H.C., Ashton, P.J., Sergeant, A., 2006. Bridging the Science-Management Divide: Moving from Unidirectional Knowledge Transfer to Knowledge Interfacing and Sharing. Ecology and Society 11(1): Art. 4.

Schulze, R.E., 2007. Some foci of integrated water resources management in the 'South' which are often forgotten by the 'North': A perspective from southern Africa. Water Resources Management 21: 269–294.

Schulze, R.E., 2008. Integrated Water Resources Management as a Medium for Adapting to Climate Change. Conceptual, scaling, impacts modelling and adaptation issues within a southern African context. In Petermann, T. (Ed.), Towards Climate Change Adaptation - Building Adaptive Capacity in Managing African Transboundary River Basins. Inwent, Zschortau, Germany, pp. 41–63.

Sherwill, T., Arendse, L., Rogers, K., Sihlophe, N., van Wilgen, B., van Wyk, E., Zeka, S., 2007. Stakeholder connectedness and participatory water resource management in South Africa. Water SA 33(4): 505-512.

Storch, von H., 2009. On adaptation – a secondary concern. Europ. Phys. J. Spec. Top. 176: 13–20.

Stuart-Hill, S.I., Schulze, R.E., 2010. Does South Africa's water law and policy allow for climate change adaptation? Clim. Dev. 2: 128–144.

Stuart-Hill, S.I., Schulze, R.E. (Eds.), 2011. An Evaluation of the Sensitivity of Socio-Economic Activities to Climate Change in Climatically Divergent south African

Catchments. WRC Report No. 1843/1/12, Water Research Commission South Africa, Pretoria, South Africa.

Taylor, A.C., 2010. Building leadership capacity to drive sustainable water management: the evaluation of a customised program. Water Sci. Technol. 61(11): 2797-2807.

Taylor, A., Cocklin, C., Brown, R., Wilson-Evered, E., 2011. An investigation of champion-driven leadership processes. Leadership Quart. 22: 412–433.

Technical Committee (TEC) GWP, 2004. Catalizing Change: A Handbook for Developing Integrated Water Resources Management (IWRM) and Water Efficiency Strategies, GWP, Stockholm, Sweden.

Termeer, C.J.A.M., 2009. Water Professionals and Public Leadership. Irrig. Drain. 58: S212–S216.

United Nations, 2013. Water Cooperation. Information Brief. Available at: http://www.un.org/waterforlifedecade/water_cooperation_2013/pdf/info_brief_water_cooperation.pdf (accessed 11 April 2013).

Vogel, C., Moser, S., Kasperson, R.E., Dabelko, G.D., 2007. Linking vulnerability, adaptation and resilience science to practice: Pathways, players and partnerships. Glo. Environ. Chan. 17: 349-364.

Wallis, P.J., Ison, R.L., 2011. Appreciating Institutional Complexity in Water Governance Dynamics: A Case from the Murray-Darling Basin, Australia. Water Resour. Manage. 25: 4081–4097.

Young, O., 2002. The institutional dimensions of environmental change: Fit, interplay, and scale, MIT Press, Cambridge.

Young, O., 2006. Vertical interplay among scale-dependent environmental and resource regimes. Ecol. Soc. 11(1): Art. 27.

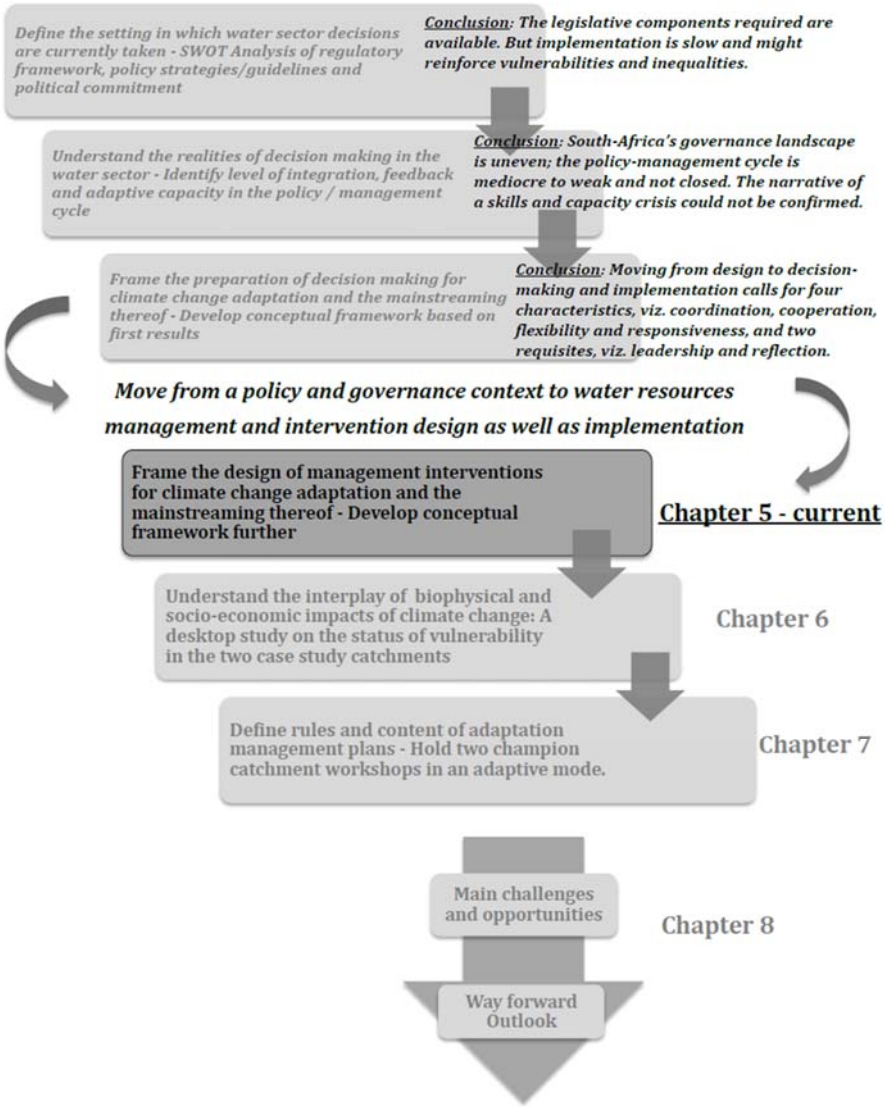
5. MAINSTREAMING ADAPTATION TO CLIMATE CHANGE: TAKING ORGANISATIONAL ISSUES INTO CONSIDERATION FOR SUCCESSFUL MANAGEMENT INTERVENTIONS

S.I. Stuart-Hill [1], C. Pahl-Wostl [2]

[1] Centre for Water Resources Research, School of Agricultural, Earth and Environmental Sciences University of KwaZulu-Natal, South Africa

[2] Institute of Environmental Systems Research, University of Osnabrück, Germany

At the time of submission of this thesis (March 2015) this chapter was in preparation for submission to the journal *Ecology and Society*, Special Feature "The Governance of Adaptation". Accordingly, the reference list adheres to the rules of that journal.



5.1 Abstract

Research, especially in the social and political sciences, agrees on the need for climate change adaptation to be tailored to local settings and, therefore, calls for an adaptive and often more integrative approach, resulting in vast amounts of information and knowledge on the complex consequences of climate change on our resources. Such knowledge would need to be mainstreamed adequately into decision-making, which places a strong emphasis on actual management and its intervention design as well as implementation when tailoring to more local settings. In the process from design to implementation, prioritisation will be needed as the limitation of capacities, finances and 'one-size-fits-all' solutions will lead to trade-offs between benefits for users and / or the environment. The aim of this paper is to design a mainstreaming approach that deals with how climate change actually translates into vulnerability of the individual and the biosphere as well as what the emerging threats to society and the economy are in order to inform water management processes and resulting interventions. In order to design and implement appropriate interventions, three key aspects have to be dealt with: incorporating and adapting to new information, vertical and horizontal integration as well as advanced monitoring. Four levels of intensity for mainstreaming have been identified, which means a significant increase in complexity when moving to higher levels intensity. This results in specific skills needed for successful mainstreaming: connective communication, complexity management, creative and visionary entrepreneurial skill. The research has also shown that it is more the organisational, and especially individual, level that matters rather than the systemic dimension of governance systems. On a systemic level climate change has often been mainstreamed into important policy and planning documents, but the research has shown that this is a 'minimum requirement'. What seems to be needed on a very personal level is the respect for other perspectives, values and priorities as well as the ability to reflect, question, evaluate and learn from what has been implemented. However, further research will be needed to look more closely at leverage points for more complex mainstreaming as well as research relating to lesser skilled environments with more fragile organisational structures, such as exist in lesser developed or developing countries.

Keywords: water management, mainstreaming, climate change, decision-making, skills

5.2 Introduction

Climate change has been declared a major economic threat of the 21st century (e.g. IPCC, 2007; UNFCCC, 2007; Bates *et al.*, 2008). The most recent IPCC report (2013) states that especially for Africa very high levels of risks exist, even if numerous adaptation activities were to unfold. Water, as the main resource of human life as well as of societal peace and economic activity is, therefore, increasingly moving into the focus of climate change impact studies as well as of debates around vulnerability[1] and resilience of human well-being (Adger, 2001 and 2006; IPCC, 2007 and 2013; Bates *et al.*, 2008; Swatuk, 2008). In the long term 'business as usual' in resource management will be expensive and not sustainable (IPCC, 2014). Policies and legal documents on a national level often frame the issue of climate change adaptation, but they themselves do not impact on the ground, which is where climate impacts are mostly experienced. Hence, management needs to include the information and growing knowledge on the complex consequences of climate change on our resources. Such knowledge has to be incorporated into decision-making processes on local, regional, national and global scales (Methmann, 2010). Decision-making is a core element of management, and when adaptation activities are designed and implemented, they are understood here as management interventions. However, decision-making is not a once off activity of adaptation, but rather a process over time that aims to "improve policy performance" (Mickwitz *et al*., 2009a, 16). It needs to be noted here that this paper uses the perspective of water and climate change in its argumentation. However, many issues discussed and concluded could be more generic.

According to Pahl-Wostl *et al.* (2012, 25), "Management refers to activities of analyzing and monitoring, developing and implementing measures to keep the state of a water resource within desirable bounds." The actual implementation of management interventions should then lead to successful adaptation which would reflect sustainable development (Chuku, 2010), reduce vulnerabilities and ensure the well-being of society under a future of climate change. Policies and legal documents create an enabling – or sometimes a disabling – environment for designing and implementing such management interventions (Stuart-Hill and Schulze, 2010) depending on how issues of fit, interplay and scales are reflected in laws, regulations and organisational design (Young, 2006; Herrfahrdt-Pähle, 2014). This is a crucial aspect for decision-making and

[1] Vulnerability here is understood as per Gallopín (2006) and Ionescu *et al.* (2005) where the external dimension of vulnerability is represented by the exposure to an impact and the relative sensitivity, while the internal dimension is the capability to cope with the impact. The latter equals the system's adaptive capacity and is a responsive element and therefore potentially can reduce vulnerability.

needs to be given appropriate attention when adaptation activities are framed and designed (Stuart-Hill *et al.*, in preparation).

Even so, understanding or being aware of climate change and its impacts does not automatically lead to adaptation activities by decision-makers (Grothmann and Patt, 2005). In particular, water managers at all governmental levels will have to mainstream climate change into their decision-making by understanding the resultant impacts as well as then adapting to these in their day-to-day work. Here a broader approach than focussing on risks and direct, visible impacts on water resource management, such as floods and droughts, has to be taken. Mickwitz *et al.* (2009a, 36) identify "adaptation issues related to agriculture, forestry impacts on ecosystems and natural habitats" as being just some of the key issues that should be included for mainstreaming climate change into the water sector. Overall the focus of understanding impacts of climate change and then designing adaptation should be more holistic than is the case nowadays in order to include the complexities of the social-ecological-system. This would also contribute to ensuring sustainable development (Chuku, 2010). In the context of climate change this calls for adaptation[2], which avoids lock-in situations, i.e. panaceas or non-reversible interventions, and inflexibility towards stresses and shocks in the future.

5.3 Setting the Scene

As any impacts of climate change on the environment probably more often than not translate into lesser or higher levels of vulnerability rather than into emerging opportunities of individuals, communities and organisations, these vulnerabilities will need to be understood in their local context and be incorporated in decision-making. Additionally, vulnerabilities may play out very differently even in close local proximity (Stuart-Hill and Schulze, 2010) and hence, not only have to be understood in their current, but also their potential future state (Stuart-Hill *et al.*, in preparation). The variety of vulnerabilities that may emerge will be competing with current ones as well as with other needs (Kabat, 2013) and thus a process is needed where vulnerabilities have to be defined and understood, followed by the negotiations of prioritising of activities. The aim of prioritisation is a key issue especially in developing countries where capacities and finances are usually limited, but also in situations where trade-offs between benefits for users and / or the environment will have to be dealt with. Such trade-offs might not be obvious, but rather be hidden and therefore need to be made

[2] Adaptation is the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007, 869).

explicit by open discussion (including the public) in order to "identify winners and losers [and] to ensure that adequate buffering systems can be put in place during transformation" (Eakin *et al.*, 2009, 223). Hence, a transparent and continual negotiation process is needed where decisions can be taken which include change of knowledge on all matters influencing the play-out of vulnerabilities in time and space. It needs to be noted here that vulnerability is understood more holistically than the descriptions given by Miller *et al.* (2010) and O'Brien *et al.* (2004). Vulnerability is understood as an existing characteristic of society that varies due to any change that is taking place (IPCC, 2014). This means that it will always be part of the start as well as the end point of an adaptation process, but that it will differ in intensity.

Based on the issues discussed above, mainstreaming needs to be purposeful (Grothmann and Patt, 2005) on the one hand, and on the other hand the preparation of a decision leading to a management intervention should be aimed at integrative and adaptive understanding and management (Stuart-Hill *et al.*, in preparation). This calls for the ability of responsiveness as well as a continual uptake of new information into decision-making processes, also in order to evaluate the negative effects and potential benefits of climate change (Muller, 2007). Therefore, the integration of climate change into decision-making cannot "take place in a vacuum – it happens within functioning policy systems at global, national, local and state levels" (Ahmad, 2009, 9). This also applies to a flexible management approach, as alluded to earlier, that reveals change and disparities over time and space, and accordingly adapts / adjusts to these. This reflects strongly the idea of mainstreaming. As Klein *et al.* (2005) define mainstreaming, it is the integration of policies AND measures into planning AND decision-making, aiming at sustainable development by reducing vulnerabilities to today's climate as well as to future climate change. Because measures of planning and resultant decision-making are framed by national politics and policies, mainstreaming in relation to policy implementation and planning reflects a strong alignment with governmental arrangements. This echoes a bias towards top-down approaches as well as sectorial issues, while the dimensions of measures and decision-making for interventions reflect regional and local governmental structures. Thus, mainstreaming also echoes a bias on local, and resultantly bottom-up, issues within a governance system.

Furthermore, decision-making requires knowledge creation especially when aiming at understanding climate change impacts, reducing vulnerabilities and ensuring overall sustainable development. Science should play a key role for water managers in contributing to such knowledge creation that guides their adaptation design. Therefore,

water management has to move towards a culture of processing “reliable knowledge”, i.e. scientific outcomes, into “socially robust knowledge” (Ison *et al.*, 2011, 3980), i.e. co-production with an emphasis on processes that are “shaped by multiple relations and reservoirs of knowledge, and a host of intermediaries and policy-brokers.” (Vogel *et al.*, 2007, 351). This includes continually moving back and forth, up and down, and even across scales and levels of governance and management.

The aim of this paper is to design a mainstreaming approach that deals with the way in which climate change actually translates into vulnerability of the individual and the biosphere, as well as what the emerging threats to society and the economy are, in order to inform water management processes and resulting interventions. In Section 5.4 the main characteristics of the mainstreaming process are examined. As mentioned earlier, an appropriate negotiation process is needed that prioritises management interventions over a defined timeline. Such interventions and their prioritisations will be based mainly on cultural and political contexts, which are reflected by domestic and international norms, as they “channel and regularise behaviour” (Finnemore and Sikkink, 1998, 894), by values and by world views. These not only change over time, but vary between societal groups and decision-makers (O’Brien, 2009), as well as other institutional and organisational factors, such as routines, cognitive views and knowledge management (Inderberg and Eikeland, 2009). Thus, context and culture may limit or constrain action (Finnemore and Sikkink, 1998); they definitely shape the options chosen and the interventions designed. This also calls for the ability of decision-makers “[…] to handle general conflicts over ideology and values” (Mickwitz *et al.*, 2009a, 12). Additionally, if the aim is more generic adaptation which goes beyond climate change, then issues of current water scarcity, population growth, decrease in natural capital (Pielke *et al.*, 2007) as well as organisational and governance weaknesses (Pahl-Wostl and Kranz, 2010) need to be included in the mainstreaming process. This results in a focus on integration across many scales and levels as well as including adaptive capacity of management interventions in themselves (*viz.* Section 5.4). The process that is required to finally implement a management intervention presents itself in Figure 5.1.

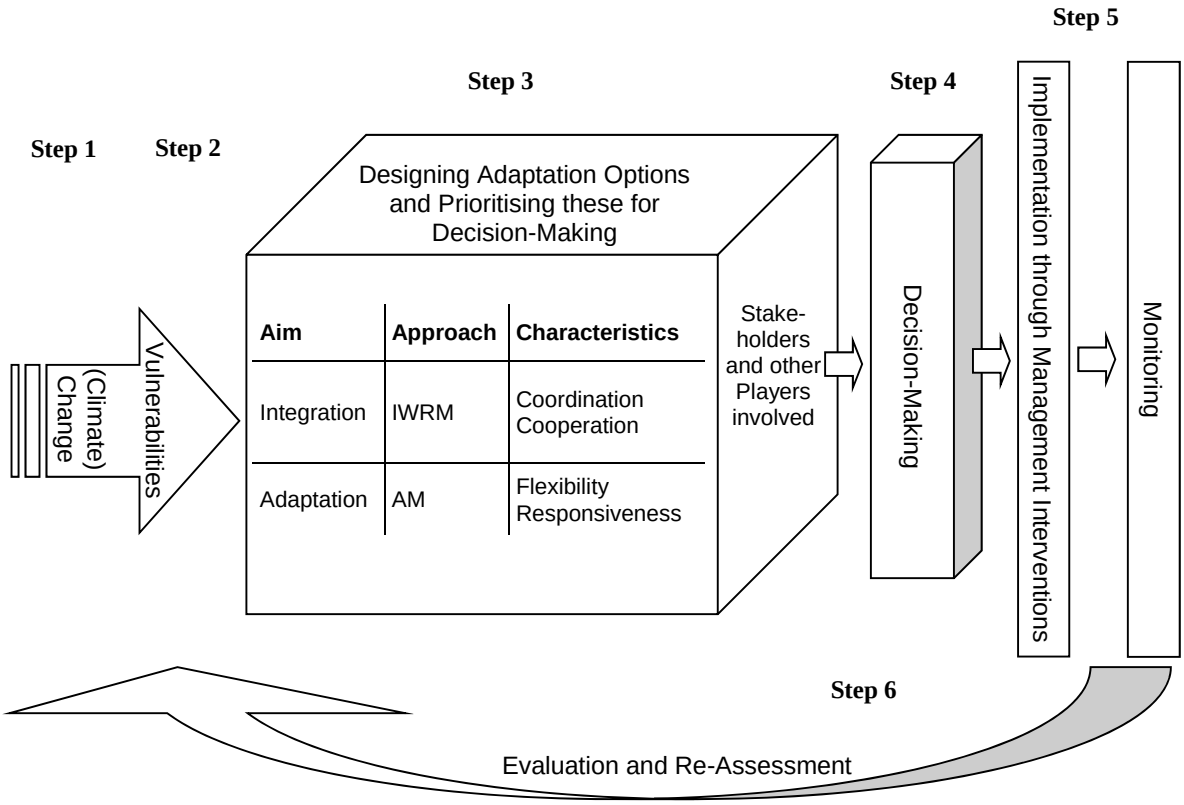


Figure 5.1 Conceptualising water governance and management interventions for adapting to climate change

5.4 Conceptual Background

All of the issues described above will lead to turbulence in the relevant organisations, as well as to change and to increasing complexities in the work of decision-makers. This can only be dealt with when "new organisational cultures, management strategies and individual competencies" (Woodhill, 2010, 55) accompany the process as suggested in Section 5.5 of this paper. Furthermore, it calls for dynamic organisations that are well informed and offer leadership that can create effective strategies when adjusting to changing circumstances (Muller, 2007).

But beyond these more theoretical and abstract issues, it is essential that policy and strategies lead to actual management interventions that are both implemented and adjusted. If that is not the case, mainstreaming might be successful on a systemic, conceptual and even legislative level, but will not lead to adaptation and change in the livelihoods of people, a robust economy and resilience of ecosystems.

Hence, the management cycle in regard to the process shown in Figure 5.1 presents itself in six essential steps:

1 Knowing impacts of change;
2 Understanding vulnerabilities (and also risks) critical at a certain time and in a certain place;
3 Making sense which results in design and prioritisation of options for adaptation;
4 Implementing management interventions for adaptation;
5 Management, monitoring and evaluation thereof; and
6 Re-assessing and adapting, based on new knowledge or understanding.

Thus, integrating new information and creating new knowledge on impacts of climate change and resulting vulnerabilities is an important aspect of the mainstreaming process (*viz.* Section 5.4.1). Another is the horizontal and vertical integration in order to negotiate potential trade-offs and prioritise activities (*viz.* Section 5.4.2). Finally, an inevitable aspect of the management cycle, and especially one for adaptive management, will be the monitoring of the implemented adaptation options as well as management itself in order to ensure sustainable development and therefore, success (*viz.* Section 5.4.3), i.e. learning from outcomes (Pahl-Wostl, 2006 and 2009) and optimising management and performance respectively (Mickwitz *et al.*, 2009a).

Another dimension that will not be touched on in this paper is that of politics. Although important for a reflexive governance approach (Voss and Bornemann, 2011) it lies beyond the scope of this paper. Nevertheless, politics will have to be reflected upon and cannot be bypassed in the real world of management and decision-making.

5.4.1 Incorporating and adapting to new information

Two main streams of new information in the context of adapting to, and mainstreaming, climate change have been identified:

(a) New and updated information from climate change science in regard to projected impacts; and
(b) New and updated information on existing and emerging vulnerabilities.

The latter is strongly determined by social entitlements and assets and, hence, a prerequisite is detailed information on individuals, communities and their livelihoods. Only then can one gain knowledge on their direct and indirect dependencies on water

and resultantly, their current as well as future emerging vulnerabilities under climate change. Therefore, the uptake of new information must occur internally (across sectors and government levels) as well as externally (e.g. by stakeholders either using, and/or impacting, water directly and indirectly; or by appreciation of the latest research outcomes). Furthermore, knowledge created from that information has to flow "unobstructed", i.e. without disciplinary fragmentation and separation from application (Roux *et al.*, 2006, 1) between science, society and management, especially in times of severe change. A shared vision might assist in seeing "themselves as part of the same community, where benefits and risks are shared" (Stirzaker *et al.*, 2011, 6). However, science can only inform and not guide the process (Methmann, 2010). New partnerships and collaborations will be needed in order to gain insights beyond ones own disciplinary perspective and also to incorporate other information types. Only then will science be able to inform policies in a productive way (Pahl-Wostl *et al.*, 2011). On the one hand, Methmann (2010) goes as far as expressing a need for decision-takers to move away from scientific knowledge as a knowledge base that mainly frames decisions of regional and national-level regimes. On the other hand, local or lower-level regimes "typically make use of forms of experiential knowledge that place a high value on place-based insights gleaned from longitudinal observations" (Young, 2006, 4). Hence, applicable or rather a relevant knowledge which is based on science and experience has to be created taking differences in "operational cultures and working philosophies into account" (Roux *et al.*, 2006, 2). In summary, integrating such information calls for essential mechanisms such as dialogue and coordination across levels and scales (Rogers *et al.*, 2000; MacKay *et al.*, 2003; TEC GWP, 2004).

Thus, to suitably mainstream climate change issues into relevant day-to-day decision-making processes for water managers and other stakeholders, several conversations are needed where local and regional knowledge on vulnerabilities (environmental, social and economic) and needs meet policy guidance (Halsnaes and Traerup, 2009; Chuku, 2010) and are placed into the 'bigger picture' of water management. Furthermore, those users that are later obliged to apply new knowledge and innovative processes need to ensure applicability and legitimacy during the development process (Roux *et al.*, 2006). Here, vertical as well as horizontal integration are key issues.

5.4.2 Vertical and horizontal integration

In the part of the management cycle described above, knowledge is being created as a starting point, based on which adaptation activities and management interventions will

then be designed. In the course of this design process conflict will be highly probable (Mickwitz *et al.*, 2009a; Ogallo, 2010) especially when trade-offs arise, and more so when the design process includes cross-sectoral and integrated activities beyond the water sector. Negotiations will have to take place which again – just as in the case of knowledge creation and understanding of vulnerabilities – will need to span scales within and outside the water sector. Resultantly, vertical and horizontal integration, i.e. the interplay and coordination between levels and sectors of management, are key concepts in order to attain a holistic approach. Figure 5.2 shows the organisational and policy canvas, based on which management interventions are designed and implemented. This shows how highly influential the national structure is with all its organisational and policy rules. In this context policy coherence is crucial in order to avoid conflicting incentives and signals (Mickwitz *et al.*, 2009a) towards water managers when designing interventions. Thus, Mickwitz *et al.* (2009b) highlight the important role of the individual in this regard as it is their own actions that need to promote objectives of climate change adaptation and mainstreaming even if their main tasks are not directly connected to these. Furthermore, with regard to Figure 5.2 Mickwitz *et al.* (2009b, 13) clarify: “Horizontal mainstreaming in this context refers to taking account of climate change throughout all government (all administrative agencies/ministries) or in numerous joint projects involving several administrative branches. Vertical mainstreaming here refers to the integration of climate issues in a single administrative sector in such a way that mitigation and adaptation are truly apparent in the concrete decisions and measures of the field of administration on the various administrative levels.” It also needs to be noted that both modes of integration, *viz.* vertical and horizontal, may, and often do, exist independently of each other.

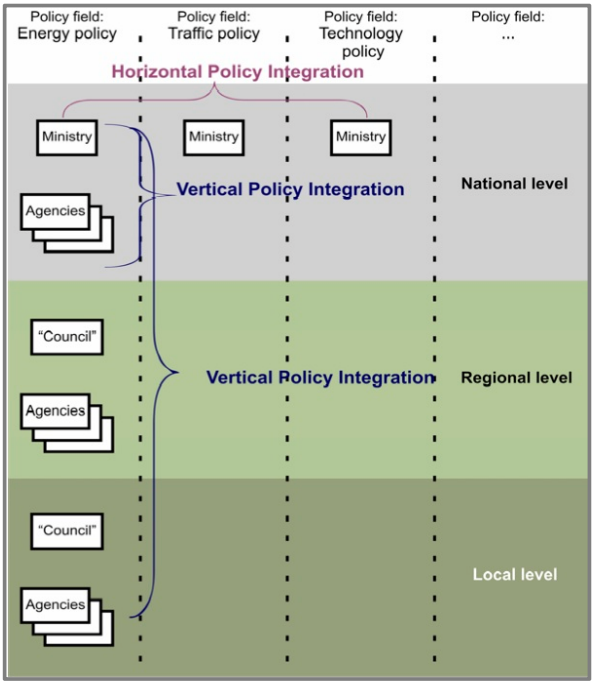


Figure 5.2 Different dimensions of vertical and horizontal climate policy integration (Mickwitz *et al.*, 2009b)

Moving from policy to management, actual interventions will have to be designed and implemented. These will be partly by regulations and partly in the form of changed practices (Mickwitz *et al.*, 2009a). Here the focus moves to the individual as well as groups of decision-makers. Their designs and negotiations will be characterised by legal frameworks and policies as well as by values, ethics and capacities (Ogallo, 2010). Cultural and political context, expressed through norms of international dimensions such as discourses within the United Nations and its member states, will be pivotal as well (Finnemore and Sikkink, 1998). This is where mainstreaming happens within and beyond the sector through interaction of formal and possibly informal organisations as well as institutionalised rules and values (making sense together and understanding, designing across scales and levels, negotiating trade-offs, prioritising strategies and activities within as well as beyond departments and hence, sectors). Urwin and Jordan (2008) note that trade-offs will appear mainly at lower levels of governance, and in particular in the implementation phase. Therefore trade-offs are a crucial dimension of mainstreaming that need to be dealt with when local management interventions are designed. Correspondingly, national policy making needs to give space for such localised design which sometimes may be inconsistent even within, for example, a given catchments.

Management often reflects the pathways of policy-making, which frequently follows the hierarchical form of governments (Koch *et al.*, 2007), hierarchies within departments as well as those from national to local level. Vertical integration is based mostly on the "formal structure of a strategic plan" (Lafferty and Hovden, 2003, 13) and therefore currently limits intervention design to the originating sector, e.g. the water sector. This might result in an easier flow of information and decisions in the arena of vertical integration (especially when higher levels of decision-makers dominate lower levels) than in regard to horizontal integration. Top-down approaches will probably also dominate because of the financial dependence of local or provincial governments on national transfer payments and hence, national preferences (Young, 2006). But it is the bottom-up processes that are important to include as they are seen to potentially reduce the uneven landscape of decision-makers and stakeholders in regard to knowledge, power, the ability to form social relations (Eriksen and Lind, 2009) as well as issues of equity and access to governance institutions (Adger, 2006). Only then can implementable and holistic activities be assured as an outcome of the interactions or 'conversations'. In such processes organisations of the state are important to provide rules and regulations to minimise the possibility of 'unruly behaviour' or even "protection from violence or policing power to enforce decisions that are subject to conflicting interests" (Eriksen and Lind, 2009, 831).

Lafferty and Hovden (2003) identify horizontal integration as being represented by a central authority's "comprehensive cross-sectoral strategy" (p.14). This is where conflict normally arises. Thus, the horizontal dimension seems to be the dimension where trade-offs would need to be discussed, negotiated and solutions found. However, there will also be trade-offs expected from vertical integration when national interests meet local ones.

Besides vertical and horizontal, integration has two other dimensions. Integration has to be object- or theme-related, for example, integrating climate change systemically into organisations and policies, as well as into discussions and decision-making (Lafferty and Hovden, 2003; Raynor and Berkhout, 2012). Integration, furthermore, has to take the individual as well as institutions and the interaction between the two into consideration (Young, 2006) in order to actually implement policies. It is especially the interactions between individuals and institutions that require "a shift in focus towards implementation and the systems of public policy and the structures and processes of public administration required to implement the concept" (Ahmad, 2009, 4). Therefore, spanning levels and scales which are desirable for mainstreaming will have to reflect a

systemic, institutional and organisational dimension (Lafferty and Hovden, 2003), i.e. “integration of policy-making as a feature of governmental steering according to differentiated sectoral responsibility” (Lafferty and Hovden, 2003, 12).

5.4.3 Monitoring

Whatever interventions are designed and implemented on whatever scale, their outcomes and actual consequences will need to be assessed. This is why Lafferty and Hovden (2003) stress the fact that mainstreaming needs to go beyond the thinking of the first generation, i.e. policy (goal), integration and needs to presume consequences and evaluations thereof. Such monitoring is challenging because, in the context of understanding vulnerabilities and climate change adaptation, incomplete knowledge and scarcity of usable data are inherent (Dasgupta and Baschieri, 2010). Here it can be helpful to widen the conversations of the management cycle to activities such as “cognitive biases”, “risk experience appraisal”, “social discourse” and “adaptation incentives” (Grothmann and Patt, 2005). Choosing properties that need to be monitored and developing relevant indicators in this regard can be quite difficult (Moser 2010; Woodhill, 2010). Furthermore, such properties might increase or decrease in importance or influence over time. As a result, detailed monitoring combined with an adaptive approach based on learning from outcomes will be crucial. In the end, decision-makers will need to deal with the fact that in complex systems such as water resources management, certain issues will have to be left out, irrespective of whether these are known or unknown to all partakers (Stirzaker *et al.*, 2010). Furthermore, the causes of vulnerability are not always direct, but might be hidden such as in a case study of Adger’s (2006) where irrigation and land tenure were the most influential determents of vulnerability. Therefore, monitoring of mainstreaming will need to include other less obvious variables than we are used to. Detailed investigations of local and regional environmental, societal and economic dependencies will assist in identifying these. A positive spin-off from such a reflected and tailored monitoring approach will be an improved learning environment as well as the creation of transparency and, therefore, accountability of actors (Mickwitz *et al.*, 2009a). The latter has the potential to build trust over time within and outside of the organisations involved in decision-making (Huntjens *et al.*, 2012), possibly leading to a clarification of responsibilities and therefore gaining accountability in the overall governance system.

5.5 The Process of Mainstreaming for Management

As mentioned earlier, mainstreaming is a dynamic process with many uncertainties (Klein *et al.*, 2005; UNDP, 2009). It is not a means to an end, but rather needs to be partially iterative and on-going in a changing environment where information and knowledge are of importance in the management process. As Lyytimäki (2010) concludes, mainstreaming needs to look at an overarching climate agenda and not only at environmental implications. It is also essential to have a broad-based debate between a "wide array of actors" (Lyytimäki, 2010, 659). Such a debate points to the crucial dimensions of moving beyond sectors as well as beyond governmental officials in order to design adaptation interventions. Kok and Coninck (2007) underline this by pointing at the potential to cross-fertilise when mainstreaming takes place across policy domains and interlinks different sectors and actors. Therefore, mainstreaming merely into the planning arena should be considered the bare minimum. Including knowledge and decision-makers outside the water sector will probably lead to a more integrated and successful approach and to better development. Additionally, coherence can be increased and trade-offs can be dealt with when cross-linking. However, in order to accommodate different capacities of regimes or governance systems, the authors suggest four levels of intensity of mainstreaming.

5.5.1 Levels of intensity of mainstreaming

The diversity of issues that are needed for successful mainstreaming are vast and interlinked. Depending on how far the conversations are widened, based on the stakeholders involved (Kok and Coninck, 2007) in the negotiations and the level of participation in the actual decision-making process, the intensity of mainstreaming can vary. That is why, in order to design practical and useful steps, we suggest four levels of intensity of mainstreaming. These are reflected in Box 5.1 by a minimal versus a maximal approach.

Box 5.1 Levels of intensity of mainstreaming climate change adaptation into management

1. Understand and include climate change into the planning of the water sector (*minimum*)
2. Integrate issues from outside the water sector (*low optimum*)
3. Understand and include climate change impacts on a relevant scale into decision making and the design of regulations within the water sector (*high optimum*)
4. Understand and include climate change into any daily decision-making and design of regulations, while simultaneously integrating issues from all other sectors (*maximum*)

The more intense, or wider, the conversation of mainstreaming is, the more the approach has the potential of designing integrative, innovative solutions as well as assuring the legitimacy of interventions taken towards the broader public in a democratic state.

Halsnaes and Traerup (2009, 776) also note, that “there is a large potential for integrating climate adaptation measures into already existing and on-going projects and planning efforts”. But this will only be possible when moving at least beyond level 1 and most probably can only be assured when mainstreaming on a level 4. Halsnaes and Traerup (2009) also suggest assessing the relationship between climate and development by defining climate variables and development indicators, linking these, and then developing adaptation options.

To keep such a diverse process transparent and understandable to the participants, a detailed communication strategy and capacity modules have to be included (Pahl-Wostl, 2007). This should increase the chance that needs and viewpoints of the different participants are understood and, in the end, sum up to a holistic and implementable strategy.

5.5.2 Increasing complexity when moving to higher intensity

Increasing the level of intensity and integration (Box 5.1, from 1 to 4) increases the complexity significantly. This is where ensuring transparency and communicating responsibilities become crucial. Decisions need to be taken by those implementing them so that they can also be held accountable for monitoring and optimising the outcomes. At the same time this will require institutional change and most probably different capacities to what is known (Snowden and Boone, 2007; Woodhill, 2010). Furthermore, the amount of data, knowledge and commitment needed for a successful process increases at the same time (Olhoff and Schaer, 2010).

The listed levels 1 and 2 in Box 5.1 only focus on planning. This is a bare minimum required for mainstreaming. There will most probably not be many trade-offs to discuss. But when the need for trade-offs does arise, power relations will become highly influential. Within government they will at the highest level become obvious in Cabinet, but there is a high probability of influencing the policy and systemic decision-making processes beforehand already.

Moving higher to levels 3 and 4, the conversation widens significantly and more decision-makers and stakeholders will need to be involved. This will lead to several challenges: trade-offs will become significantly more relevant, knowledge, and hence known vulnerabilities, will increase and more requirements/demands will have to be satisfied. Power relations will also come strongly into play. Overall, "the challenge at hand is to integrate different, but equally valid, approaches to knowledge rather than to start with a one-sided perspective and to add insights from the other perspective at the margin" (Young, 2006, 9).

Especially when increasing complexity and also when aiming at management interventions, there is a "need [for] scientific knowledge to be translated into robust guidelines, and identifying a requisite simplicity may provide this" (Stirzaker *et al.*, 2010, 1). In the context of water management and adaptation design this could be done by identifying key hydrological drivers that are representing most issues in a specific area on a spatial and/or temporal scale. A known example for this is using modelled system yield in water management as the only parameter in order to plan infrastructure, or mimic streamflow, for water availability. Using these in isolation is not advisable as they ignore many aspects of the wider catchment and societal context. However, these limitations can be dealt with when taking transdisciplinary aspects into consideration (Jones, 2011).

However, when implementing such an approach it is crucial to keep in mind that "motivation and perceived abilities are important determinants of human action" (Grothmann and Patt, 2005, 208). Hence, in the decision-making process and during any negotiations, possible and implementable management interventions have to accompany the conversations. If these were linkable to key governmental activities such as the identification of infrastructure design or other economic investments (Matthews *et al.*, 2011; Kabat, 2013), then win-win situations can emerge which enable the process of mainstreaming. Such key activities could, therefore, serve as nuclei for the mainstreaming of the climate change debate itself. When risks as well as adaptation options are communicated concurrently the other relevant sectors might 'get the message' and be prepared to act. One aspect that needs to be taken into consideration though, has been highlighted by Rayner and Berkhout (2012, 30), *viz.* "soft incentives [such as persuasion and socialisation] are insufficient to stimulate much mainstreaming", but they also identify a window of opportunity when hard, i.e. technological, incentives offer win-win solutions. Mainstreaming then has a greater chance of implementation.

Overall, many of the adaptation options that are designed will have legitimacy, but in an institutional, organisational and knowledge environment would have limited predictability and those taking decisions would require “a deep understanding of context” (Snowden and Boone, 2007, 76) resulting in specific skills that will be needed for successful mainstreaming.

5.5.3 Skills needed for successful mainstreaming

What are the specific skills needed by management and decision-makers to mainstream issues such as climate change adaptation into planning, design and implementation of management interventions? Three main challenges regarding the required skills arise from the defined levels of intensity for mainstreaming:

(a) There is a need for connection in the sense of cooperation and coordination of organisations and individuals beyond their day-to-day work, which normally is focussed on colleagues and activities within one department on one governmental level. This connective communication skill is needed to ensure the inclusion of new information, the creation of new knowledge and an enhanced understanding of vulnerabilities.

(b) The increasing complexity implies dealing with more diverse knowledge and also negotiating trade-offs between players and sectors in order to prioritise and implement management interventions. This complexity management skill has two dimensions: the individual and his / her organisation: On the one hand it calls for the ability of the individual to appreciate different views and be able to change working and thinking approaches according to the problem at hand. At the same time the individual has to be practical in designing interventions and have the courage and technical skill to simplify context down to appropriate key variables, including a specific hydrological response (e.g. baseflow), an economic indicator (e.g. industrial production) or societal capacity (e.g. livelihood assets). On the other hand organisational culture needs to offer and build trust towards and around those individuals, especially trust by top-management and politicians.

(c) Ways of innovation have to be found in a rather rigid organisational way of operation, as Olsson *et al.* (2006) have demonstrated regarding the utilisation of windows of opportunity that may play a crucial role. This relates to a creative and visionary entrepreneurial skill that would need to include creative thinking and solution seeking. Most probably an existing visionary outlook of the

> individual, for example, knowing how the single decision fits into the long-term development of water resources, would be rather helpful here.

Overcoming these challenges and the change and transformation they imply calls for appropriate, i.e. situation dependent, leadership and learning capacities within and beyond organisations, as many authors have identified (e.g. Kok and Olsson *et al.*, 2006; Kok and Coninck, 2007; Inderberg and Eikeland, 2009; Ison *et al.*, 2011; Pahl-Wostl *et al.*, 2011). Olsson *et al.* (2006) go as far as stating that management is needed to a far lesser degree, but that a process is needed to govern negotiations and learning. However, both capacities will need critical reflection that lies outside the scope of this paper. Here it needs to be remembered that individuals can have very non-altruistic reasons that may undermine or counteract the shared vision of moving forward and finding solutions. Especially in times of "crises, rapid change, and turbulence" we are "susceptible to toxic leaders", as Lipman-Blumen (2005, 30) argues. In the context of this paper her suggestions could be translated into defining doable goals on a practical time line, dealing openly with any emotions arising in the process (e.g. anxiety and angst) and accepting that uncertainty was, and always will be, part of the process.

In the process of mainstreaming certain individuals have to be identified who are able to transcend scales within the originating sector and beyond, as well as "moving" horizontally and vertically. Such individuals may demonstrate the identified leadership skills (Olsson *et al.*, 2006) especially when collaborating in governance networks by providing "key functions for adaptive governance, such as building trust, making sense, managing conflict, linking actors, initiating partnerships among actor groups, compiling and generating knowledge, and mobilizing broad support for change" (Folke *et al.*, 2005, 8.11). However, depending only on these individuals during the process of solution-finding and decision-making would be inconsiderate. The transparency and openness, i.e. accessibility for individuals to enter and leave the process, of the conversations taking place are vital to the success of mainstreaming.

The learning dimension in the context of this paper is basically an optimisation process: as we move forward we learn, based on our experiences, but we also incorporate new knowledge built by reflecting on decisions taken, facilitating ones own learning as well as that of groups and organisations. It will also enable decision-makers to share a large interface with sustainable development (Klein *et al.*, 2005) which, especially in the developing world, is critical. Learning in this context will also need to engage politically and be self-reflective (Woodhill, 2010). With only few individuals displaying

such a wide set of attributes, this leads us again to the significance of certain skills: leaders and other decision-makers who are capable of arguing, reflecting on their own as well as on the assumptions, perspectives and values of others and utilising certain organisational and individual relationships.

5.6 Conclusions

Although an enabling environment for the mainstreaming of climate change at the present point in time should at minimum be achieved on a systemic level in order to provide an enabling environment, this is by far not enough. Real and successful management interventions for climate change adaptation call for a better and more holistic understanding of impacts of climate change and existing as well as emerging vulnerabilities. Especially the latter will need to be dealt with, aiming at more local discussion and solution finding processes, also to make final management interventions more relevant and implementable. Organisational and individual levels beside the systemic level are even more critical, as this paper has demonstrated.

Generally the mainstreaming of climate change is a highly complex task when taken seriously and when simultaneously aiming at sustainable development in the long-term. It includes a variety of actors within and outside of government, who communicate and negotiate across levels and scales. This will only be possible when actors meet on a playing field where power differences are minimised, and where more or less everyone is trusted and respected by their counterparts, based on their respective expertise and knowledge. Leadership plays a key role here, but anyone in the process should have certain skills such as relevant technical expertise, the ability to process new information and for systems thinking, experience in their profession as well as having at least some institutional memory. What also seems to be needed on a very personal level is the respect for other perspectives, values and priorities as well as the ability to reflect, question, evaluate and learn from what has been implemented.

The suggestions on the mainstreaming process and the capacity and skills needed by the actors will take time to implement and build. They demand new partnerships, potentially new organisational arrangements and a strong focus on gathering a variety of socio-economic information that has to be included in robust and continuous monitoring processes. Such a management style needs financial commitment and political will. However, it will surely be possible to identify windows of opportunity for policy as well as management to start implementing certain aspects of the suggested process.

Such innovations, or best practices, could be nuclei for up- and out-scaling and include a motivation for learning and partaking in new conversations in other departments, communities and networks.

The latter would need to be further researched. It would also be important to investigate the relevance of knowledge brokers or boundary organisations as leverage points for more complex mainstreaming. In the context of the developing world where the greatest need for mainstreaming exists and current levels of vulnerability are high already, it would be of interest to discuss the suggested concepts in light of a lesser skilled environment as well as in light of more fragile organisational structures.

Last, but not least, mainstreaming and the skills required for it will push us beyond what we currently know in regard to thinking, communication and decision-making. It will demand a lot from the individual as well as the organisations involved. However, if sustainable development under climate change is to be achieved we will need to invest into this. In the field of water, as our main resource of life, of societal peace and economic activity and, consequently, of prosperity, this should be worth the effort.

5.7 Acknowledgements

The authors wish to thank the Water Research Commission for their financial support in this research. Furthermore, acknowledgements go to Dr Richard Meissner of the CSIR and Dr Kathrin Knüppe of the University of Osnabrück for their comments on earlier versions of this paper.

5.8 References

Adger, W. N. 2001. Scales of governance and environmental justice for adaptation and mitigation of climate change. *Journal of International Development* 13: 921-931.

Adger, W. N. 2006. Vulnerability. *Global Environmental Change* 16:268–281.

Ahmad, I. H. 2009. Climate policy integration: Towards operationalization. DESA Working Paper No. 73 ST/ESA/2009/DWP/73 March 2009.

Bates, B. C., Z. W. Kundzewicz, S. Wu, and J. P. Palutikof (eds.). 2008. Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change. IPCC Secretariat, Geneva, Switzerland.

Chuku, A.C. 2010. Pursuing an integrated development and climate policy framework in Africa: options for mainstreaming. *Mitigation and Adaptation Strategies for Global Change* 15: 41–52.

Dasgupta, A., and A. Baschieri. 2010. Vulnerability to climate change in rural Ghana: Mainstreaming climate change in poverty-reduction strategies. *Journal of International Development* 22: 803–820.

Eakin, H., E. L. Tompkins, D. N. Neson, and J. M. Anderies. 2009. Hidden costs and disparate uncertainties: trade-offs in approaches to climate policy. In: Adger, W. N., Lorenzoni, I., O'Brien, K.L. (Eds) Adaptation to Climate Change: Thresholds, Values, Governance. Cambridge University Press, Cambridge, UK. Chapter 13, 212-226.

Eriksen, S., and J. Lind. 2009. Adaptation as a political process: Adjusting to drought and conflict in Kenya's drylands. *Environmental Management* 43: 817–835.

Finnemore, M., and K. Sikkink. 1998. International norm dynamics and political change. *International Organization* 52: 887-917.

Folke, C., T. Hahn, P. Olsson, and J. Norberg. 2005. Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources* 30: 8.1–8.33.

Gallopín, G. C. 2006. Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change* 16: 293–303.

Grothmann, T., and A. Patt. 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change* 15(3): 199–213.

Halsnaes, K., and S. Traerup. 2009. Development and climate change: A mainstreaming approach for assessing economic, social, and environmental impacts of adaptation measures. *Environmental Management* 43: 765–778.

Herrfahrdt-Pähle, E. 2014. Applying the concept of fit to water governance reforms in South Africa. *Ecology and Society* 19(1):25, Special Feature: Nudging Evolution? Critical Exploration of the Potential and Limitations of the Concept of Institutional Fit for the Study and Adaptive Management of Social-Ecological Systems.

Huntjens, P., L. Lebel, C. Pahl-Wostl, J. Camkin, R. Schulze, and N. Kranz 2012. Design propositions for the governance of adaptation to climate change in the water sector. *Global Environmental Change* 22: 67–81.

Inderberg, T. H., and P. O. Eikeland. 2009. Limits to adaptation: analysing institutional constraints. In: Adger, W.N., Lorenzoni, I., O'Brien, K.L. (Eds) Adaptation to Climate Change: Thresholds, Values, Governance. Cambridge University Press, Cambridge, UK. Chapter 27, 433-447.

Ionescu, C. R., J. T. Klein, J. Hinkel, K. S. Kavi Kumar and R. Klein. 2005. Towards a Formal Framework of Vulnerability to Climate Change. FAVAIA Working Paper 1 (NeWater Working Paper, 2). Potsdam Institute for Climate Impact Research, Potsdam, Germany.

IPCC 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, USA.

IPCC 2014. Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, USA.

Ison, R., K. Collins, J. Colvin, J. Jiggins, P. P. Roggero, G. Seddaiu, P. Steyaert, M. Toderi, and C. Zanolla. 2011. Sustainable catchment managing in a climate changing world: New integrative modalities for connecting policy makers, scientists and other stakeholders. *Water Resources Management* 25(15): 3977-3992.

Jones, J. A. 2011. Hydrological responses to climate change: considering geographic context and alternative hypotheses. *Hydrological Processes* 25(12): 1996-2000.

Kabat, P. 2013. Water at a crossroads. Interview. Nature Climate Change 3: 11-12.

Klein, J. T., L. F. Schipper, and S. Dessai. 2005. Integrating mitigation and adaptation into climate and development policy: three research questions. *Environmental Science & Policy* 8: 579–588.

Koch, I. C., C. Vogel, and Z. Patel. 2007. Institutional dynamics and climate change adaptation in South Africa. *Mitigation Adaptation Strategies for Global Change* 12: 1323-1339.

Kok, M. T. J., and H. C. de Coninck. 2007. Review widening the scope of policies to address climate change: directions for mainstreaming. *Environmental Science & Policy* 10(7-8): 587–599.

Lafferty, W., and E. Hovden. 2003. Environmental policy integration: towards an analytical framework. *Environmental Politics* 12(3): 1-22.

Lipman-Blumen, J. 2005. Toxic leadership: When grand illusions masquerade as noble visions. *Leader to Leader* 36: 29-36.

Lyytimäki, J. 2010. Mainstreaming climate policy: the role of media coverage in Finland. *Mitigation and Adaptation Strategies for Global Change*, 16(6): 649–661.

MacKay, H. M., K. H. Rogers, and D. J. Roux. 2003. Implementing the South African water policy: Holding the vision while exploring an uncharted mountain. *Water SA* 29(4): 353-359.

Mathews, J. H., B. A. J. Wickel, and S. Freeman. 2011. Converging currents in climate-relevant conservation: Water, infrastructure, and institutions. *PLoS Biology* 9(9): e1001159.

Methmann, C. P. 2010. 'Climate protection' as empty signifier: A discourse theoretical perspective on climate mainstreaming in world politics. *Millennium: Journal of International Studies* 39(2): 345–372.

Mickwitz, P., F. Aix, S. Beck, D. Carss, N. Ferrand, C. Görg, A. Jensen, P. Kivimaa, C. Kuhlicke, W. Kuindersma, M. Máñez, M. Melanen, S. Monni, A. B. Pedersen, H. Reinert, and S. van Bommel. 2009a. Climate Policy Integration, Coherence and Governance. PEER Report No 2. Helsinki: Partnership for European Environmental Research, pp 93.

Mickwitz. P., P. Kivimaa, M. Hildén, A. Estlander, and M. Melanen. 2009b. Mainstreaming climate policy and policy coherence. A background report for the compiling of the foresight report of Vanhanen's second government. Prime Minister's Office Publications 21/2009. Dnro:1770/20/2007 Printed by Helsinki University Print, Helsinki 2009, pp 75.

Miller, F., H. Osbahr, E. Boyd, F. Thomalla, S. Bharwani, G. Ziervogel, B. Walker, J. Birkmann, S. van der Leeuw, J. Rockström, J. Hinkel, T. Downing, C. Folke, and D. Nelson. 2010. Resilience and vulnerability: Complementary of conflicting concepts? *Ecology and Society* 15(3): 11.

Moser, S. C. 2010. Now more than ever: The need for more societally relevant research on vulnerability and adaptation to climate change. *Applied Geography*, 30(4): 464-474.

Muller, M. (lead author). 2007. Climate Change Adaptation and Integrated Water Resource Management – An Initial Overview. Policy Brief 5. Technical Committee (TEC), GWP, Stockholm, Sweden.

O'Brien, K., S. Eriksen, A. Schjolden, and L. Nygaard. 2004. What's in a word? Conflicting interpretations of vulnerability in climate change research. CICERO Working Paper 2004:04, Oslo, Norway. pp 16. http://www.cicero.uio.no

O'Brien, K. L. 2009. Do values define the limits to climate change adaptation? In: Adger, W.N., I. Lorenzoni, and K. L. O'Brien (eds.) Adaptation to Climate Change: Thresholds, Values, Governance. Cambridge University Press, Cambridge, UK. Chapter 10, 164-180.

Ogallo, L. 2010. The mainstreaming of climate change and variability information into planning and policy development for Africa. *Procedia Environmental Sciences*, 1: 405–410.

Olhoff, A., and C. Schaer, C. 2010. Screening Tools and Guidelines to Support the Mainstreaming of Climate Change Adaptation into Development Assistance – A Stocktaking Report. UNDP: New York.

Olsson, P., L. H. Gunderson, S. R. Carpenter, P. Ryan, L. Lebel, C. Folke, and C. S. Holling. 2006. Shooting the rapids: navigating transitions to adaptive governance of social-ecological systems. *Ecology and Society* 11(1): 18.

Pahl-Wostl, C. 2006. The importance of social learning in restoring the multifunctionality of rivers and floodplains. *Ecology and Society* 11(1): 10.

Pahl-Wostl, C. 2007. Transitions towards adaptive management of water facing climate and global change. *Water Resource Management* 21: 49-62.

Pahl-Wostl, C. 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change* 19: 354-365.

Pahl-Wostl. C., and N. Kranz. 2010. Water governance in times of change. *Environmental Science and Policy* 13: 567-570.

Pahl-Wostl, C., P. Jeffrey, N. Isendahl, and M. Brugnach. 2011. Maturing the new water management paradigm: Progressing from aspiration to practice. *Water Resources Management* 25(3): 837-856.

Pahl-Wostl, C., L. Lebel, C. Knieper, and E. Nikitina. 2012. From applying panaceas to mastering complexity: Towards adaptive water governance in river basins. *Environmental Science and Policy* 23: 24-34.

Pielke, R. Jr., Prins, G., Rayner, S., Sarewitz, D. 2007. Lifting the taboo on adaptation. *Nature* 445(9 February): 597-598.

Raynor, T., and F. Berkhout. 2012. EU Climate Policy Mainstreaming Background paper for RESPONSES/ IEEP symposium. 12th July 2012 Nether-ER, Brussels. Pp 38.

Roux, D. J., K. H. Rogers, H. C. Biggs, P. J. Ashton, and A. Sergeant. 2006. Bridging the science-management divide: Moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecology and Society* 11(1): 4.

Rogers, K., D. Roux, and H. Biggs. 2000. Challenges for catchment management agencies: Lessons from bureaucracies, business and resource management. *Water SA* 26(4): 505-511.

Snowden, D. J., and M. E. Boone. 2007. A leader's framework for decision-making. *Harvard Business Review* November 2007: 69-76.

Stirzaker, R., H. Biggs, D. Roux, and P. Cilliers. 2010. Requisite simplicities to help negotiate complex problems. *AMBIO* 39(8): 600-607.

Stirzaker, R. J., D. J. Roux, and H. C. Biggs. 2011. Learning to bridge the gap between adaptive management and organisational culture. *Koedoe* 53(2): 1007.

Stuart-Hill, S. I., E. Herrfahrdt-Pähle, and C. Pahl-Wostl. (in preparation). Mainstreaming adaptation: Preparing decision-making in the water sector. *Environmental Science and Policy*.

Stuart-Hill, S. I., and R. E. Schulze. 2010. Does South Africa's water law and policy allow for climate change adaptation? *Climate and Development* 2: 128–144.

Swatuk, L. A. 2008. A political economy of water in southern Africa. *Water Alternatives* 1(1): 24-47.

Technical Committee (TEC) GWP. 2004. Catalizing Change: A Handbook for Developing Integrated Water Resources Management (IWRM) and Water Efficiency Strategies, GWP, Stockholm, Sweden.

UNFCCC. 2007. Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Information Services of the UNFCCC secretariat, Bonn, Germany. Pp 68. http://unfccc.int/resource/docs/publications/impacts.pdf

UNDP. 2009. Adaptation definitions and levels. Web-based: http://www.undp.org/climatechange/adapt/definitions.html#11.

Urwin, K., and A. Jordan. 2008. Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance. *Global Environmental Change* 18: 180-191.

Vogel, C., S. Moser, R. E. Kasperson, and G. D. Dabelko. 2007. Linking vulnerability, adaptation and resilience science to practice: Pathways, players and partnerships. *Global Environmental Change* 17: 349-364.

Voss, J-P., and B. Bornemann. 2011. The Politics of Reflexive Governance: Challenges for Designing Adaptive Management and Transition Management. *Ecology and Society* 16(2): 9.

Woodhill, J. 2010. Capacities for institutional innovation: A complexity perspective. *IDS Bulletin* 41(3): 47-59.

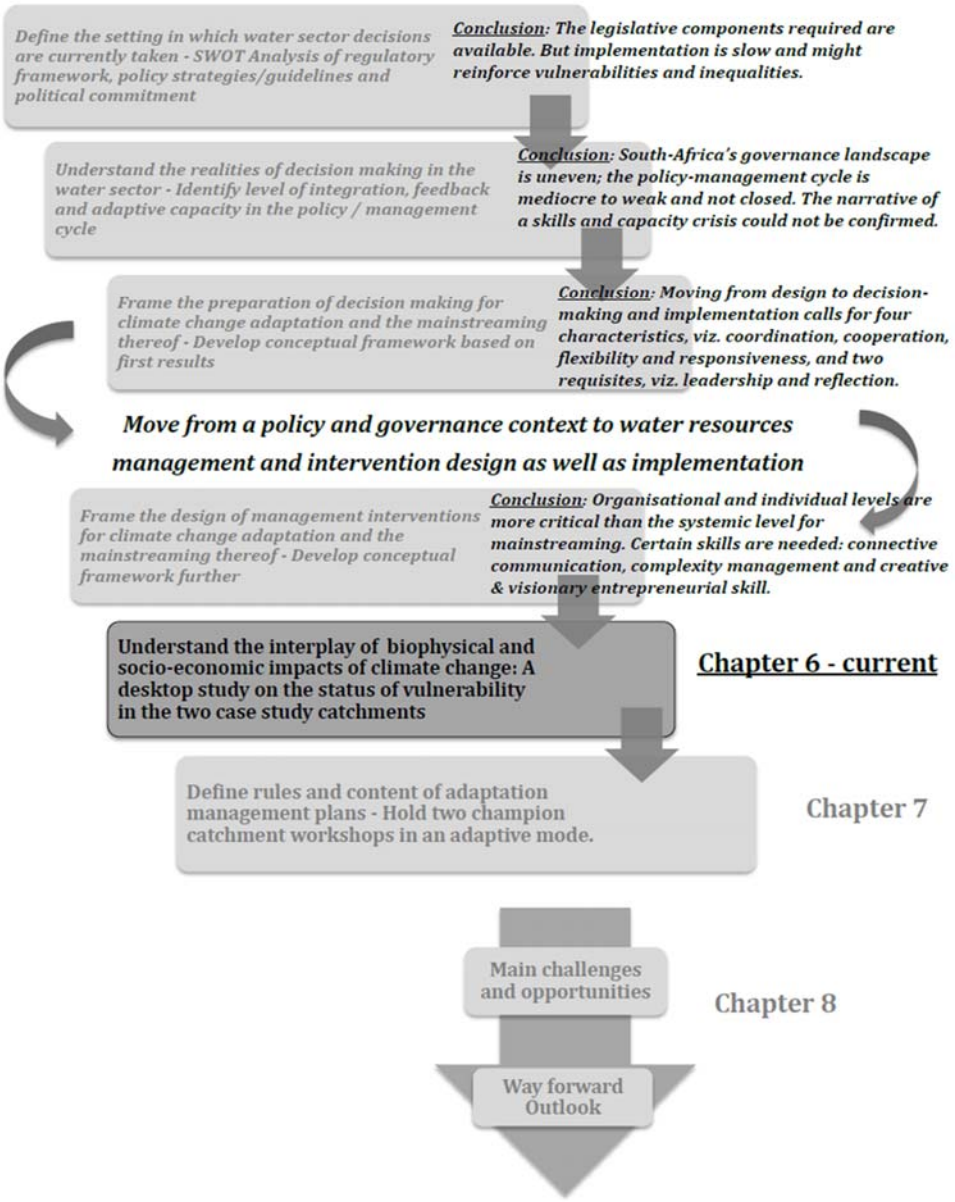
Young, O. 2006. Vertical interplay among scale-dependent environmental and resource regimes. *Ecology and Society* 11(1): 27.

6. UNDERSTANDING LINKS BETWEEN WATER AND SOCIETAL VULNERABILITY TO IDENTIFY CLIMATE CHANGE HOTSPOTS IN SOUTH AFRICA

S.I. Stuart-Hill, L.M. Bulcock and R.E. Schulze

Centre for Water Resources Research; School of Agricultural, Earth and Environmental Sciences; University of KwaZulu-Natal, Pietermaritzburg, South Africa

At the time of submission of this thesis (March 2015) this chapter was in review with the journal *Water SA*. Accordingly the reference list adheres to the rules of that journal.



6.1 Abstract

Research should assist in identifying vulnerable communities which should then become primary targets for adaptation strategies to help reduce impacts of climate change. If early action were to be taken, and by that possibly even gaining beneficial trade-offs from climate change, this would enhance greater safety to society, the environment and the economy. Such an approach contrasts with the simplistic assumption often made that regions experiencing high levels of climate change will also be the most vulnerable, or that high levels of poverty equate to high vulnerability in the context of water availability. By combining modelled climate change impacts - focused on water availability - using the ACRU hydrological model and data from the 2001 South African population census (which at the time of writing was the latest available) a first attempt is made to identify areas of vulnerability in two climatically divergent South African catchments, *viz*. Primary Catchment G which includes the Berg and Breede river catchments in the Western Cape province and Primary Catchment U which includes the Mgeni, Mvoti, Umkomaas and Umzimkulu river catchments in KwaZulu-Natal. In order to describe vulnerability from an integrated perspective, indicators of adaptability, sensitivity and risk were used. Results show that simplistic assumptions such as high levels of climate change impacts equalling high levels of vulnerability, or rural poverty generally displaying high levels of vulnerability, can be misleading. The major conclusion is that designing adaptation options for especially poorer communities for projected future climatic conditions needs a much more concise assessment of local societal and economic dependencies on climate related hydrological responses and the natural resource base than was hitherto believed.

Key Words: climate change, impacts, vulnerability, adaptation

6.2 Introduction

As concern about global climate change increases and it is becoming generally accepted by policy makers, researchers and the public at large, so also has research into the concept of vulnerability to climate change increased (e.g. Ionescu *et al.*, 2005; Adger, 2006; Fuessel, 2010; Hinkel, 2011; Hjerpe and Glaas, 2012). While the need to research, develop and implement plans to mitigate impacts of climate change is imperative, acknowledgement of the need to simultaneously develop and implement adaptation plans in order to counter projected effects of climate change is equally important (von Storch, 2009). Even if we were to rapidly decrease greenhouse gas

emissions into the atmosphere with immediate effect, the lag effect on climate would see communities still bearing the impacts of climate change for many decades to come (IPCC, 2014). As part of an effective adaptation plan the identification of those communities most vulnerable to climate change is imperative, irrespective of their adaptive ability and the overall resilience of society, the environment and the economy. However, because communities display high levels of disparities amongst one another and disparities exist even within a single community (e.g. Ziervogel *et al.*, 2006; Reid and Vogel, 2006; Plummer and Slaymaker, 2007; Füssel, 2010), this calls for uniquely designed adaptation strategies. This is true also for South Africa, which to this day still suffers under the planning and infrastructural design footprint of the colonial and apartheid eras, which is partially the cause of the dual economy existing in the country. Climate change is likely to further aggravate existing societal and economic imbalances, and enhanced climate and hydrological variability is projected to exacerbate the exposure to extreme events as well as to seasonal climate shifts (Schulze, 2012). Thus, with action taken as early as possible, and as a consequence of early action possibly even gaining beneficial trade-offs from climate change, this could enhance greater safety to society, the environment and the overall economy, rather than assuming simplistically that regions projected to experiencing high levels of climate change to also be the most vulnerable, or that high levels of poverty would equal high vulnerability to climate change. Especially in regards to the latter, Dasgupta and Baschieri (2010, 814) have shown "that the standard definition of poverty is not a good measure to define them most vulnerable."

Founded on the above argumentation, this paper therefore makes a first attempt at identifying localized vulnerability to climate change in selected catchments in South Africa in an integrated manner, in an approach similar to that used by Hjerpe and Glaas (2012). It needs to be noted here that the authors are of the opinion that science needs to guide our understanding of climate change impacts, of emerging vulnerabilities and, in the long-run, of adaptation design and decision-making. Consequently, the resource base (in this case water resources) plays an important and integral part when discussing existing as well as emerging vulnerabilities. Note that projected temperature and water quality related impacts of climate change are not considered in this paper.

A first step taken was to define the term vulnerability as it is relevant in a South African context and to unravel its three primary dimensions, *viz.* exposure, sensitivity and adaptive capacity (*cf.* Section 6.3). The methodology used was to combine climate scenarios with economic and societal data (*cf.* Section 6.4). The latter was gained from

the South African Population Census of 2001, which at the time that this research was undertaken was the latest available at fine spatial resolution. The overall goal of this paper is to show a way forward when assessing climate change impacts and, further down the line, to gain some answers which are relevant for policy making, policy implementation and local water management practices (*cf.* Section 6.5). It needs to be noted here that the information and maps acquired were used for so-called "workshops of champions" held in 2011 (Champion Workshop Berg Catchment, 2011; Champion Workshop Mgeni Catchment, 2011) in the two climatically contrasting South African catchments selected for this study, *viz.* Primary Catchment U, in this paper sometimes also called the Mgeni case study area, and Primary Catchment G, hereafter sometimes also called the Berg-Breede case study area.

6.3 Defining Vulnerability

Conventionally, vulnerability to climate change has been interpreted as the gap between the changes that would take place due to climate change within a system and the system's ability to adapt to that change (IPCC, 2007 and 2014). It was seen as a net impact of the climate problem, and could be represented as a relative or comparative change expressed in terms of monetary costs, changes in yield or damage to ecosystems (Blennow and Persson, 2009). Adger (2006) considers vulnerability to be a present state which renders a system unable to cope with external changes, for example a change in climate. In relation to human populations, vulnerability is a characteristic of the current socio-economic status of a group of people, which leaves them unable to protect themselves or recover from a change in their environment. Already this definition of vulnerability poses the question, "Who is vulnerable to climate change and why?" and aims at identifying ways to reduce this vulnerability (O'Brien *et al.*, 2004; Blennow and Persson, 2009).

However, more appropriate for this research (in the opinion of the authors) are Ionescu *et al.* (2005) and Gallopin's (2006) approach where vulnerability is hypothesised to have an internal and external dimension. The external dimension is the exposure to an impact as well as the relative sensitivity, while the internal dimension is the capability to cope with the impact, which is equivalent to the degree of the system's adaptive capacity (Gallopin, 2006). Consequently, vulnerability is "determined by social entitlements" (Adger, 2001; 925) and the property of 'adaptive capacity' as a responsive element can mitigate impacts and therefore reduce vulnerability to a certain extent (Ionescu *et al.*, 2005). For example, adaptive capacity can potentially increase, and

therefore vulnerability correspondingly decrease, in accordance with the degree of mobility as well as availability of financial means. However, both actions pre-suppose information and knowledge on the matter in order to act. Poor communities are therefore highly vulnerable and are likely to be seriously affected (Reid and Vogel, 2006), largely because they do not have the relevant knowledge, nor the finances, to adapt and they mostly depend on either a single resource or only a few resources for their livelihood. Nonetheless, it cannot, and should not, be assumed that regions experiencing high levels of projected climate change will also be the most vulnerable, or that high level of poverty equal high vulnerability.

This research therefore aims at first identifying which communities are more sensitive to climate change than others as a result of their socio-economic status; secondly, how able those communities are to respond to the climate and water related risks imposed on them and, thirdly, what the likelihood of risks are that these communities are most exposed to. *Adaptability* may be defined as the response capacity of a community. It is their ability to make informed decisions about the risk which projected climate change imposes on them and then their ability to use this information to protect themselves against the threats, or to react and recover from the effects of the threats. *Sensitivity* to impacts is characterised by the communities' dependency on the resources around them. Those people who are directly dependent on resources (such as water) around them are likely to be affected by any changes in the availability and distribution of those resources. If climate change affects the availability or distribution of the resources on which the community depends, then the ability of the community to adapt and secure their livelihoods will be compromised. *Exposure*, i.e. likelihood of impact posing a *risk* to stressors and hazards, can be characterised as the probability of a physical impact being imposed on a community (Blennow and Persson, 2009). This may be in relation to the physical location of people, for example, those living adjacent to a river are at greater risk to projected increased flooding. By analysing the distribution of these three characteristics, we can identify which communities are more vulnerable to climate change than others and focus adaptation plans on these communities.

6.4 Materials and Methods

In order to gain some insight into projected impacts of climate change, the daily time step physical-conceptual ACRU agrohydrological simulation model (Schulze, 1995 and updates) was used to generate hydrological output using daily climate input from climate scenarios of the five IPCC global change models (GCMs) (Solomon *et al.*,

2007), *viz*. CGCM3.1 (T47), CNRM-CM3, ECHAM5/MPI-OM, GISS-ER and IPSL-CM4, based on the A2 emissions scenario. These GCMs had been empirically downscaled by the Climate Systems Analysis Group at the University of Cape Town to climate station level in South Africa for a present time period (1971 – 1990), an intermediate (2046 – 2065) and a more distant (2081 – 2100) time period (Lumsden *et al.*, 2010). Combining this with detailed spatial data from the latest available population census (2001) at the time of the research in 2011, areas of vulnerability were identified. Two climatically and socio-economically divergent South African catchments were chosen in order to cover aspects of projected climate change in what were considered to be two hotspots of concern, *viz*. Primary Catchment G which includes the Berg and Breede catchments in the winter rainfall region of the Western Cape province with projected decreases in rainfall and corresponding runoff (Schulze, 2012), which is in contrast to the summer rainfall region's Primary Catchment U which includes the highly developed Mgeni catchment in KwaZulu-Natal in which increases in rainfall and runoff are projected (Schulze, 2012).

6.4.1 Quinary Catchments Database

Climate change projections across South Africa were undertaken at the spatial resolution of Quinary Catchments (Schulze and Horan, 2010) of which 5 838 cover South Africa, Lesotho and Swaziland. Each Quinary has been delineated to be a relatively homogeneous hydrological and agricultural response zone with similar climate, soils and land use. The Quinaries are linked to the South African Quinary Catchment Database (QnCDB; Schulze *et al.*, 2012), developed within the (then) School of Bioresources Engineering and Environmental Hydrology (SBEEH) at the University of KwaZulu-Natal. To each Quinary is linked a data file of daily temperature, relative humidity, solar radiation, potential evaporation and rainfall for the historical period 1950 – 1999, as well as data files with the same daily climate variables from the climate change projections of the 5 GCMs listed above for each of the 3 time periods mentioned (Schulze *et al.*, 2012). Using these climate inputs, second order outputs such as runoff, design rainfall and flood volumes, peak discharge, irrigation water requirements and groundwater recharge could be simulated using the ACRU model.

6.4.2 The 2001 Population Census Data

Population related data were extracted from the 2001 National Population Census (Statistics South Africa, 2003), which includes personal population details such as age, gender, population group etc., as well as socio-economic data such as home language, highest education levels, income, type of settlement and access to water related services.

Using the SUPERTable 2.0 function, relevant census data sets (as described in Table 6.1) were selected at the level of sub-place (which is the equivalent of a suburb) within the magisterial district of a province. A table was created and exported into ArcView 3.2. Certain problems with the dataset have been identified and acknowledged by the Census Committee (Statistics South Africa, 2003). The problems identified include both under- and over-estimations of the distribution of age in both children and the aged, over-estimation of unemployment and under-estimation of household income. These problems are generally recognised as problems associated with all censuses and especially those conducted in developing countries. While these problems may have an effect on the actual number of vulnerable people in a community, the overall trends will most likely not be influenced too greatly (Statistics South Africa, 2003). One of the problems arising from the use of this dataset was the geographic scale at which data were available. While the level of a sub-place is sufficient for suburbs and more rural areas, it lacked sufficient detail in highly populated areas surrounding major cities. This may therefore present problems in high density areas associated with cities where vulnerable communities may be living in close proximity to less vulnerable communities within the same suburb, but because the spatial resolution is not fine enough to differentiate these communities, some important detail may be lost.

In order to allow for easy comparison between the two datasets, the population census data were first extracted and then aggregated to match the Quinary Catchment delineations to utilise the information from the Quinary Catchments Database. In order to achieve this, the Two Themes Analysis Extension application in Arcview 3.2 was applied. ‘The Aggregate’ function was used, which aggregates data based on the proportion of area one theme intersects on the second theme. This recalculates the distribution of the population census data to the area of the Quinary. This may result in slight inaccuracies with the redistribution of population statistics, but overall trends are likely to remain representative.

6.4.3 Indicators of vulnerability

Based on the three main characteristics of vulnerability discussed above when defining the term, the indicators chosen to describe vulnerability for this study are listed in Table 6.1 below.

Table 6.1 Descriptions of the adaptability, sensitivity and risk indicators of vulnerability used in this study

Variable	Description	Data Source	Characteristics Limiting or Increasing the Respective Indicators
Adaptability			
Age	< 15 or > 69 years Or 15 – 69 years	Population Census	Reduced mobility. Increased probability of dependence on others for knowledge, finances and assistance.
Education	Grade 11 or lower	Population Census	Lack of knowledge to make informed decisions. Reduced employment options, which reduces ability to move to safer environments.
Income	a) Below the poverty line (< R400 / month) b) Low income (< R1 600 / month)	Population Census	Reduced ability to take precautionary action against threats or to recover from impacts. Lack of resources to move to safer environments.
Sensitivity			
Water from Open Sources	Dams, pools, stagnant water, rivers and streams	Quinary Catchments	Streamflow
Water from Rainfall Tanks	Water harvested from rainfall	Quinary Catchments	Rainfall
Water from Boreholes	Water pumped from a borehole	Quinary Catchments	Groundwater recharge
Irrigation Water Requirements	Water collected from streamflow for the purpose of irrigating commercial and subsistence crops	Quinary Catchments	Changes in irrigation demands, changes in streamflow and changes in evaporation
Risk			
Proximity to rivers	Risk of flooding	Quinary Catchments	Peak discharge

6.5 Results

In this section the results of the mapping process are presented and discussed. As already mentioned, two Primary Catchments were studied, *viz*. Primary Catchment U located along the eastern seaboard of South Africa in the province of KwaZulu-Natal and Primary Catchment G in the southwest, located in the province of the Western Cape.

6.5.1 Primary Catchment U (including the Mgeni River Catchment)

Primary Catchment U includes two major cities, Pietermaritzburg (the capital of KwaZulu-Natal) and Durban (South Africa's third largest city with Africa's largest port). The catchment is made up of a mix of land uses, including urban settlements, rural areas, subsistence and commercial farming as well as various open spaces and degraded areas.

Figure 6.1 identifies the location of communities considered to have a low response capacity, based on education levels and income, in and around the two major urban areas, *viz*. the cities of Durban and Pietermaritzburg, as well as along the coastal strip north of Durban up to Stanger. Very low levels of income are considered to influence peoples' abilities to take precautionary actions to protect their lives and property against impacts of climate change, while low education levels could imply a lack of access to knowledge about the threats of climate change, as well as limiting peoples' options regarding moves to safer locations and having access to employment. High density settlements characterise urban settlement patterns, implying that a large number of people, living in a relatively small area, are potentially vulnerable to climate change impacts. Urban migration may have a negative effect on peoples' ability to adapt to climate change as they experience disruptions in social structure and lose traditional practices (Grothmann and Patt, 2005). This presents a challenge to city managers and decision-makers when implementing adaptation plans to help protect a large number of highly vulnerable people. The Quinary catchments, outlined in black in the figures that follow, indicate communities where the population comprises predominately of people below 15 and above 69 years of age, implying further possible restrictions on these communities' ability to respond to climate change challenges. To add a further vulnerability pressure, many of these communities have a major river running through the settlements they occupy, leaving them vulnerable to risks of flooding.

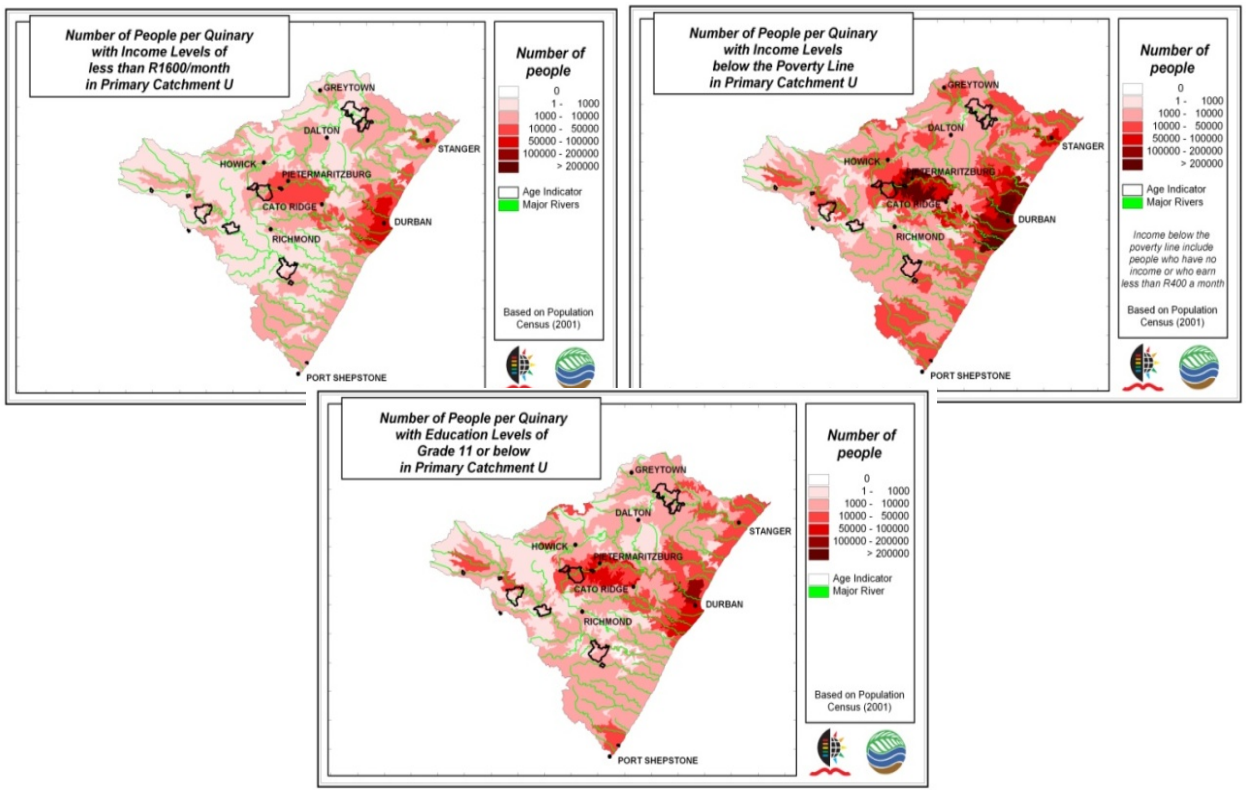


Figure 6.1 Income and education criteria indicating potential risks and responses, i.e. adaptive capacities, of communities within Primary Catchment U to climate changes (Information source: StatsSA, 2003)

Figure 6.2 shows the communities which, according to the 2001 population census, were directly dependent on open water sources as their main water source. The largest numbers of people reliant on open water sources are found around Pietermaritzburg, Port Shepstone and Stanger. These people are directly dependent on streamflow to fulfil their water requirements. Making use of the median of the ratio of changes derived from outputs of the multiple GCMs used in this study stresses the magnitude of the projected change of mean annual accumulated streamflow. Thus, the map on the right in Figure 6.2 constitutes that under climate change conditions the mean annual streamflows are projected to increase significantly around Pietermaritzburg and Stanger and somewhat less so around Port Shepstone, resulting in more water being available for use. However, the seasonal distribution of streamflow may change and inter-annual flows may become more variable, so further studies into the projected consistency of streamflow throughout the year should be undertaken. Nevertheless, using open water sources as a main supply of water has various social and health issues. Open water is susceptible to upstream contamination which may make water unsuitable for human use

and lead to the spread of waterborne diseases; the latter being more probable under climate change because of an increase in air as well as water temperature (CDC, 2012). Plans to improve access to water, especially in these communities, should thus still be a major focus of planners.

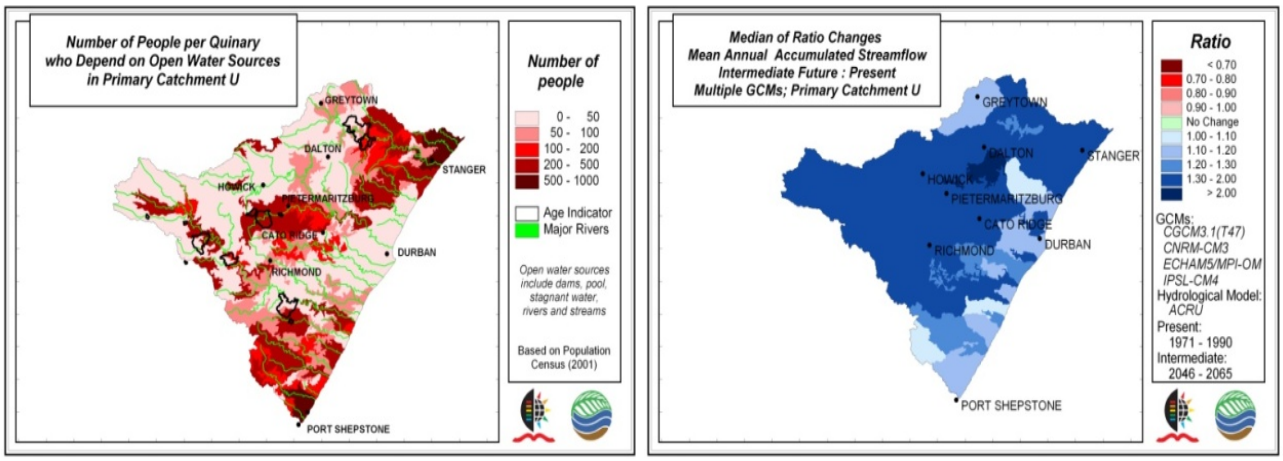


Figure 6.2 Open water source dependency (left), indicating potential sensitivity of communities within Primary Catchment U to water availability from streamflows, as well as (right) projected changes in mean annual streamflows into the intermediate future (Information sources: StatsSA, 2003 and Schulze, 2012)

Figure 6.3 identifies those communities which are directly dependent on rainfall collected in rain water tanks as their main water source. There are fewer people who rely on rain water tanks for water than those who rely on open water sources. Most of these people are found around Stanger and Port Shepstone, and to a lesser extent around Pietermaritzburg. Changes in rainfall may affect the availability of water to these communities. However, it may be seen that under projected climate change conditions rainfall in the wet season, represented by January, remains relatively unchanged; therefore if the tanks are fulfilling the current household requirements, they should continue to do so under climate change conditions. Rainfall in the traditionally dry season, represented by July, is projected from output of multiple GCMs to increase under climate change conditions in the main areas where rainfall water harvesting is practised. However, there are areas where some people are using rainfall tanks, just north of Port Shepstone and around Pietermaritzburg, where dry season rainfall is projected to decrease. Assuming that the projections are correct, these people may be vulnerable to seasonal water shortages under future climatic conditions.

Figure 6.4 identifies the location people who rely on borehole water to supply their water needs. The highest numbers of these are found around Pietermaritzburg, Stanger and Port Shepstone. Projections into changes in groundwater recharge, which would sustain the borehole water supply, into the intermediate future show overall increases, implying more water potentially being available for water abstractions from boreholes. Almost double the amount of recharged water is projected from the multiple GCMs to be available around Pietermaritzburg and Stanger, while Port Shepstone is expected to have 10 % to 20 % more recharged water available. Projected increases in the availability of groundwater may make the introduction of new boreholes in areas currently not making use of this water source a viable adaptation strategy for the future.

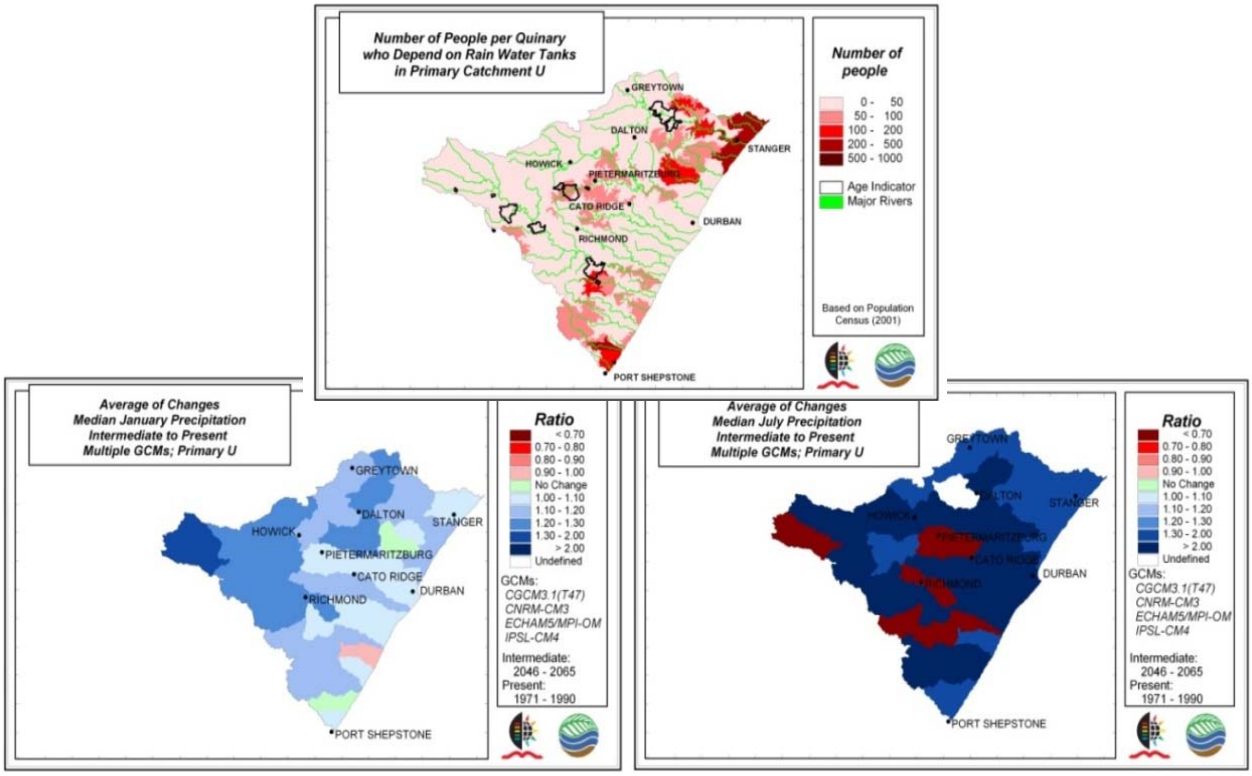


Figure 6.3 Rain water tank dependency (top), indicating potential sensitivity of communities within Primary Catchment U to seasonal rainfall amounts, as well as projected changes in January (bottom left) and July (bottom right) rainfall into the intermediate future (Information sources: StatsSA, 2003 and Schulze, 2012)

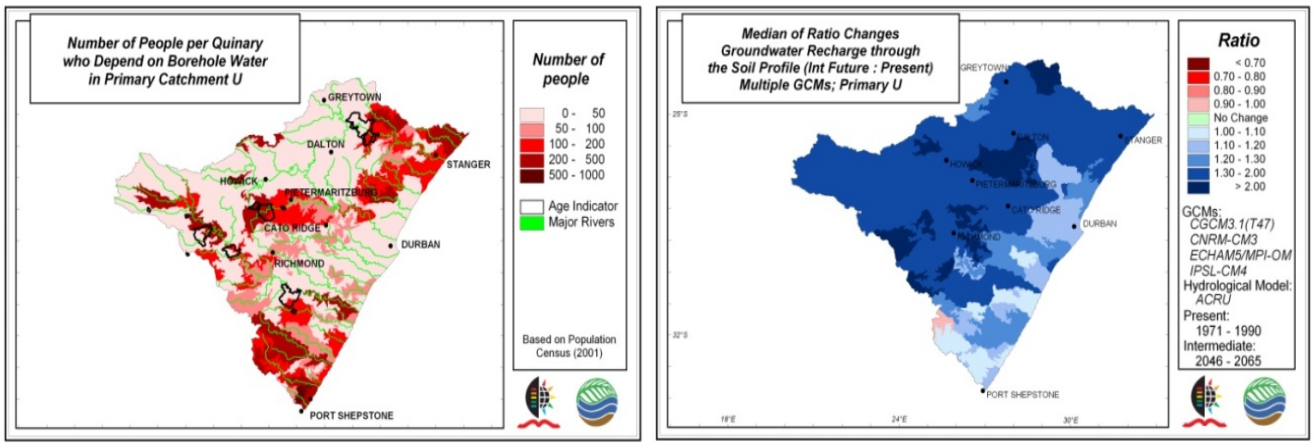


Figure 6.4 Borehole water as the main water source (left), indicating the potential sensitivity of communities in Primary Catchment U to groundwater recharge, as well as (right) projected changes in groundwater recharge into the intermediate future (Information sources: StatsSA, 2003 and Schulze, 2012)

In Figure 6.5 the spatial distribution of informal and traditional households is shown. These households are hypothesised to have a high risk of damage from intense rainfall events and flash flooding as their building materials and structure often lack the structural integrity to withstand the pressures of heavy rains and associated flood waters. Projected changes in short duration heavy rainfall events show a slight increase across most of the catchment. However, of greater concern are the large projected changes in three day flood events (i.e. long duration floods), especially in the interior around Pietermaritzburg where there are a high number of informal houses, often located in the floodplains. Projected increases in long duration flood events could place these already vulnerable people at even greater risk.

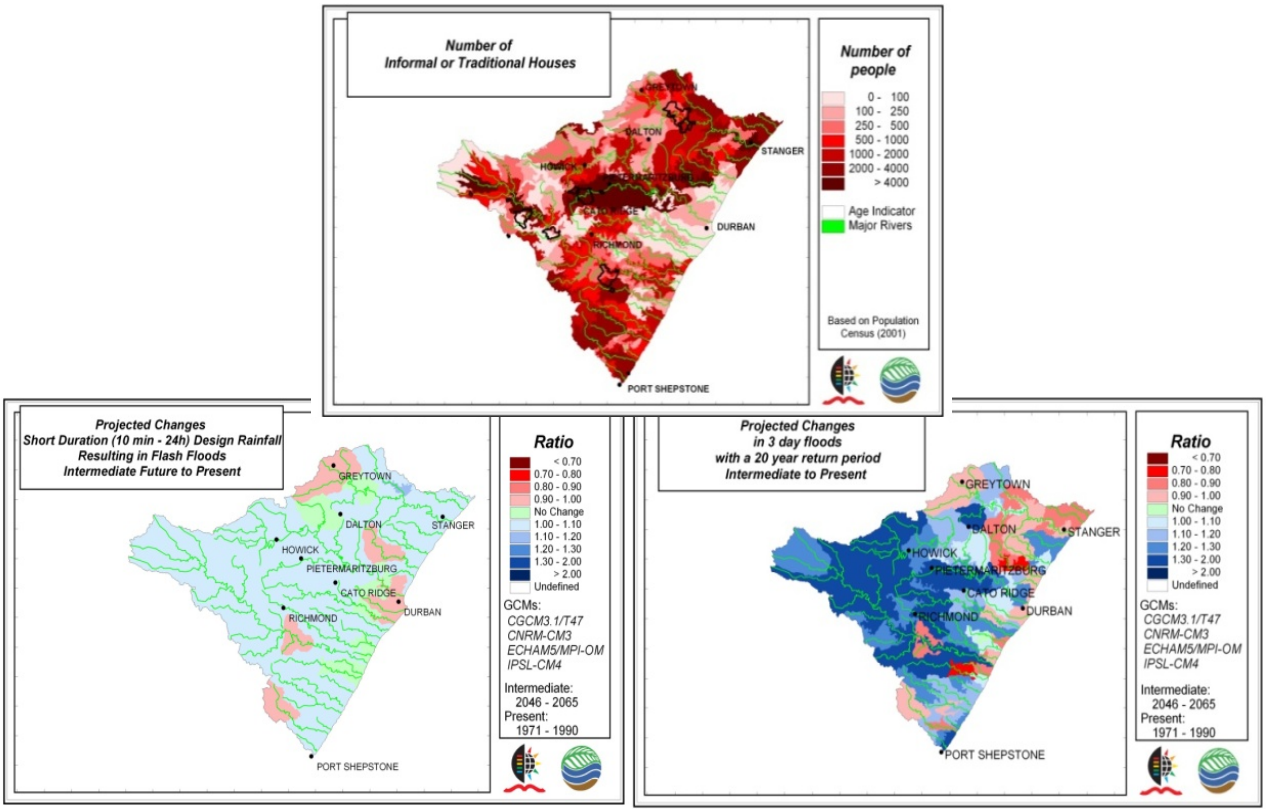


Figure 6.5 The number of informal or traditionally structured households which are at high risk of damage due to heavy rainfalls and resultant flooding (top), as well as projected changes in (bottom left) short duration high intensity rainfall events and (bottom right) 3 day flood events in Primary Catchment U (Information sources: StatsSA, 2003 and Schulze, 2012)

Overlaid with the low income and low education levels shown in Figure 6.1, one can identify people who are considered highly vulnerable to changes in climate because they:

(a) are at risk due to their social status and housing situation,

(b) have reduced response capacity due to their low income and low education levels, and

(c) are largely dependent on the water sources in their immediate vicinity.

6.5.2 Primary Catchment G (including the Berg and Breede River Catchments)

The second catchment studied was Primary Catchment G, which includes the highly irrigated Berg and Breede systems. This catchment is situated in the winter rainfall region of the Western Cape province along the west and south coasts of South Africa and supplies the City of Cape Town (South Africa's second largest city) with water. The catchment consists of a mixture of land uses, including urban settlements, rural areas, subsistence and commercial farming (dryland wheat and mainly irrigated export orientated high value deciduous fruit products), as well as containing various open spaces and degraded areas.

Figure 6.6 identifies the location of people in and around Cape Town who are considered to have a low response capacity, based on low education levels and low income, with the highest concentration immediately adjacent to the city emanating from large informal settlements such as Khayelitsha. Such large numbers of vulnerable people pose a challenge to city managers and decision-makers when designing and implementing feasible climate change adaptation plans.

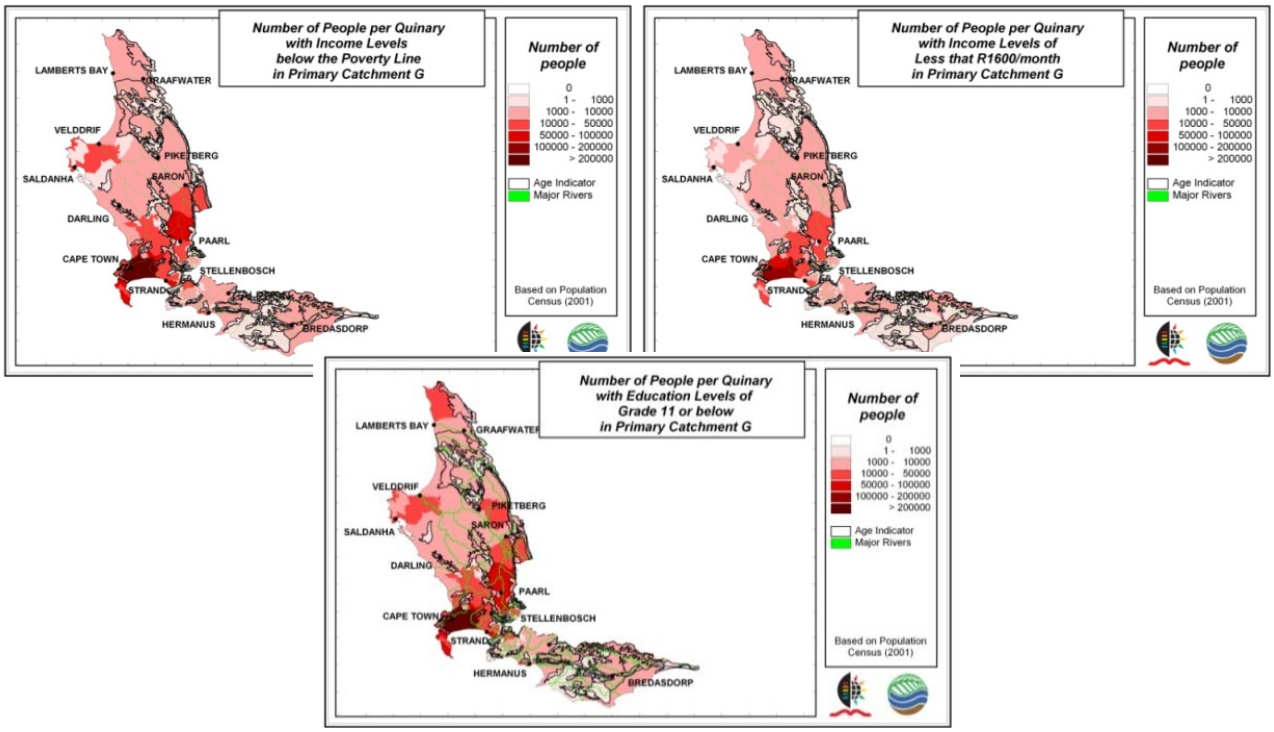


Figure 6.6 Income and educational criteria indicating potential risks and responses, i.e. adaptive capacities, of communities within Primary Catchment G to climate changes (Information source: StatsSA, 2003)

The Quinary Catchments outlined in black in the figures which follow indicate communities where the population comprises predominately of people in the < 15 and > 69 age group, implying further possible restrictions on these communities' ability to respond to climate change challenges. Additionally, many of these communities have a river running through them, leaving them vulnerable to risks of flooding.

Figure 6.7 shows locations of communities which are directly dependent on open water sources as their main water source. Compared to Primary Catchment U in KwaZulu-Natal, the census data here indicate low numbers of people dependent on open water sources, with only small concentrations around the city of Cape Town and the area around Paarl. However, of concern are indications that already into the intermediate future around the 2050s annual streamflows are projected to decrease by between 10 % and 20 % in these areas, resulting in less water being available from rivers and dams. Additionally, people who use open water sources in this study area are already at risk because the water sources are of low water quality, resulting in the water often being unfit for human use and susceptible to the spread of diseases (Görgens and de Clercq, 2005; Champion Workshop Berg Catchment, 2011 and 2012; Champion Workshop Mgeni Catchment, 2011 and 2012). Changes in the availability of water further highlight the urgent need to provide alternative water sources to these communities and their individuals in order to reduce their vulnerability. These communities are most vulnerable to many changes, including climate change, and therefore seem to need prioritisation when adaptation plans are designed.

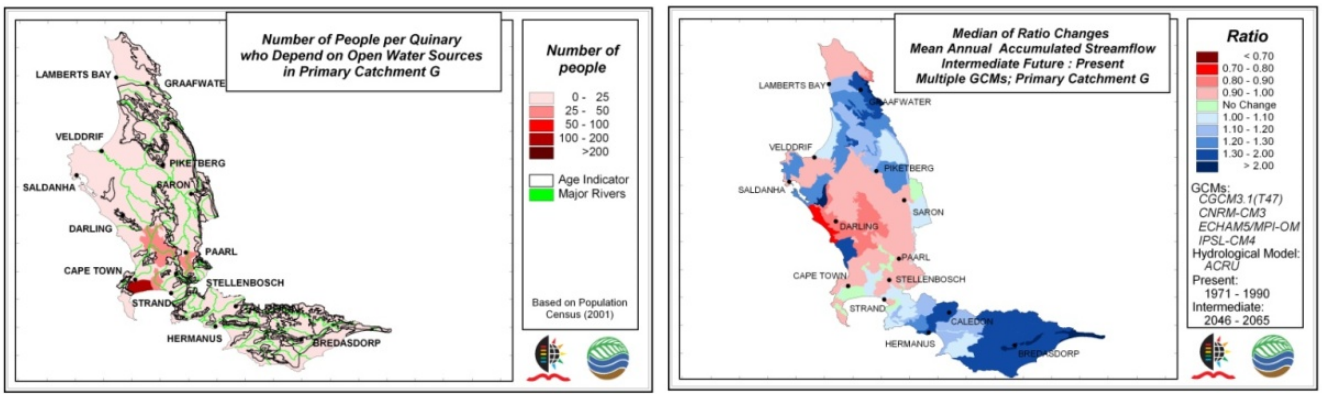


Figure 6.7 Open water source dependency (left), indicating potential sensitivity of communities within Primary Catchment G to water availability from streamflows, as well as (right) projected changes in mean annual streamflows into the intermediate future (Information sources: StatsSA, 2003 and Schulze, 2012)

In Figure 6.8 the communities which are directly dependent on rainfall collected in rain water tanks as their main water source are identified. The number of people who rely on rain water tanks is relatively low, with most of them residing around the city of Cape Town. Unfortunately analyses of changes in January (i.e. summer) rainfall are difficult to interpret as this is the dry season in the Western Cape with its mediterranean climate, when water is less available than at other times of the year. While some results show a slight increase in rainfall during summer, the levels of certainty are low because changes come off a low base (Schulze, 2012). However, according to the outputs from those GCMs used in this study, projected changes in winter rainfall, which is the rainy season in the Western Cape, show increases into the intermediate future, which should result in a higher availability of water for rainwater harvesting. The latter may therefore become a viable adaptation option.

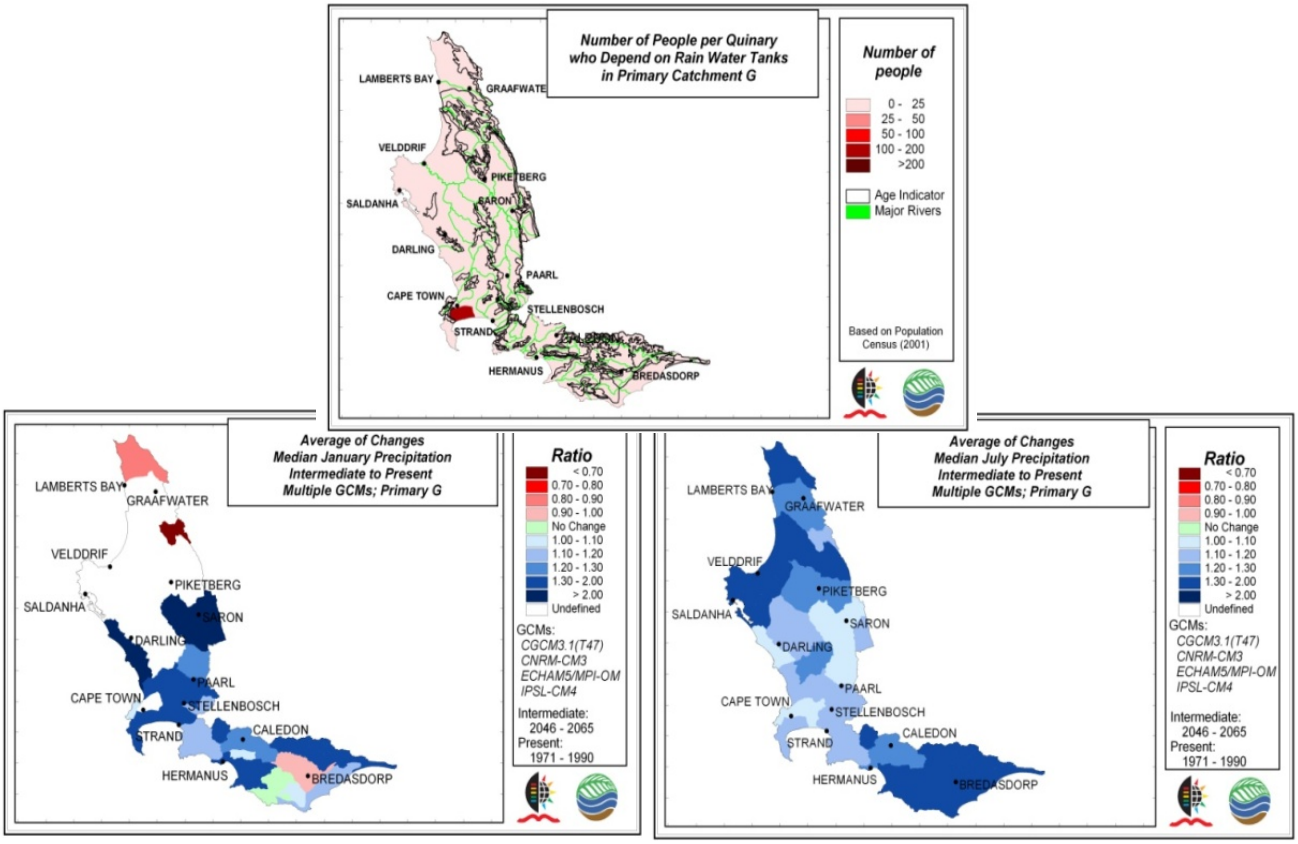


Figure 6.8 Rain water tank dependency (top), indicating the potential sensitivity of communities within Primary Catchment G to seasonal rainfall, as well as (bottom left) projected changes in January (dry season) and July (wet season) rainfall into the intermediate future (Information sources: StatsSA, 2003 and Schulze, 2012)

Use of boreholes as the main source of water (Figure 6.9) is again low in Primary Catchment G, with concentrations of people dependent on this source of water found around the city of Cape Town, the area of Paarl and to the north up to Lamberts Bay. Therefore, where projected decreases in groundwater recharge are shown in Figure 6.9 (right), those areas could present future problems in the availability of water for borehole abstraction. Alternative sources of water may need to be identified for these people in the future.

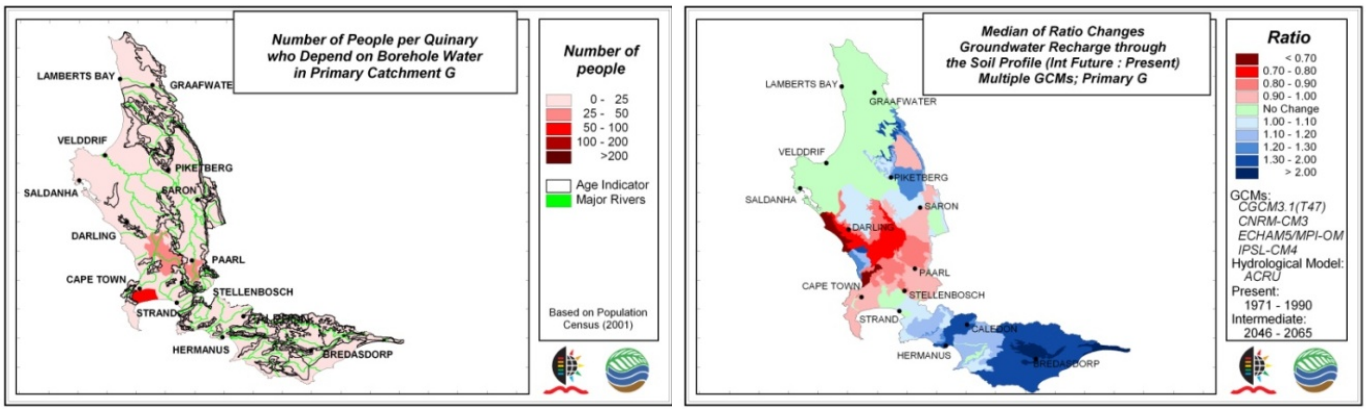


Figure 6.9 Borehole water dependency as the main water source (left), indicating potential sensitivity of communities in Primary Catchment G to groundwater recharge, as well as (right) projected changes in annual groundwater recharge into the intermediate future (Information sources: StatsSA, 2003 and Schulze, 2012)

Figure 6.10 shows the location of informal or traditional households. These households are considered at risk of damage from heavy rainfall and flooding. Projected changes in heavy rainfall events of short duration show a slight increase in some areas of Primary Catchment G; however, for most areas such events are not projected to increase in the future. Decreases in three-day (i.e. long duration) floods are also projected over most of the study area, but with increases projected in some areas in the north and the east. However, those areas have few informal or traditional houses; therefore increases in the risk of flooding may not be of major concern to the management of human settlements within the catchment than at present.

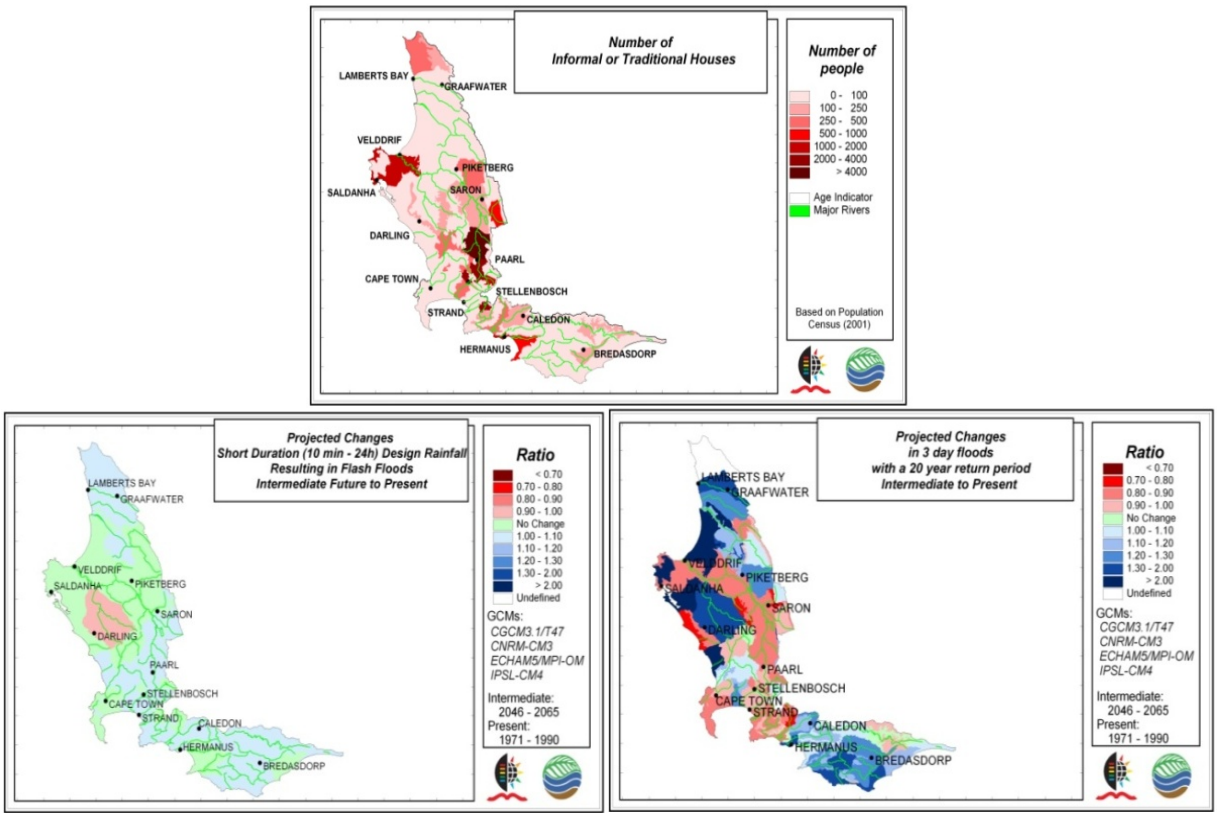


Figure 6.10 The number of informal or traditionally structured households which are considered at high risk of damage due to heavy rainfalls and resultant flooding (top), as well as projected changes into the intermediate future of short duration high intensity rainfall events (bottom left) and 3 day flooding (bottom right) in Primary Catchment G (Information sources: StatsSA, 2003 and Schulze, 2012)

Impacts of climate change on irrigation of both commercial and subsistence crops could have a severe impact on economic activities in the already highly irrigated Berg and Breede systems which make up the bulk of Primary Catchment G (Figure 6.11), as projected changes in streamflows, which supply the irrigation water, into the intermediate future indicate a decrease around Cape Town in both years of median flows as well as in the 1:10 high flow year (Figure 6.11). However, in drier years, streamflows are projected to increase in comparison to present conditions. In addition to the irrigation water demands, which from a climate perspective alone are projected to increase by between 10 and 20 % (Figure 6.11, bottom left; Schulze, 2012), there may be water shortages for other sectors as less streamflow is projected to be available to meet increasing demands. The changes in streamflows and in irrigation demand already factor in the significant projected increases in reference (i.e. potential) evaporation

(Figure 6.11, bottom right), and the overall supply of water for all sectors, but especially for irrigation purposes, may become an acute source of vulnerability under climate changed conditions.

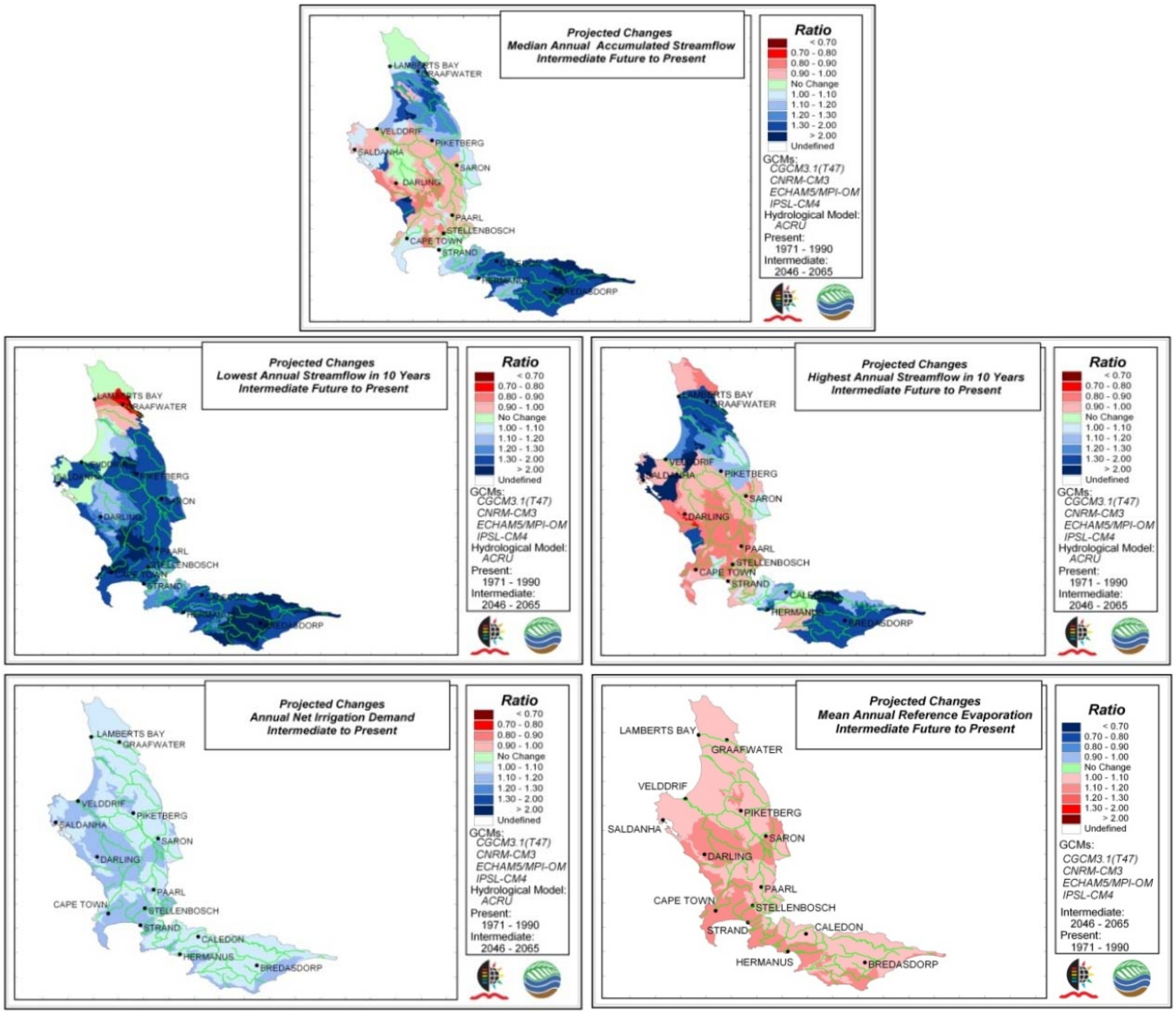


Figure 6.11 Projected changes from the present into the intermediate future in mean annual accumulated streamflows (top), lowest and highest annual streamflows in 10 years (middle row), net irrigation demand (bottom left) and reference potential evaporation (bottom right) in Primary Catchment G (Information source: Schulze, 2012)

6.6 Discussion and Conclusions

Up to this point the level of vulnerability to climate change of communities has been discussed separately in each of the two study catchments. It was found that each catchment contains areas that are considered either more vulnerable or less vulnerable when taking account of education levels, income levels and the age distribution of the population. The adaptability of those communities to climate change is considered to be compromised due to their inability to make informed decisions, or their inability to cope with or adapt to the projected perturbations in climate and their hydrological consequences. Furthermore, there needs to be differentiation as to what type of vulnerability is displayed by the data in order to design appropriate and feasible adaption strategies: For example, communities in Primary Catchment U in KwaZulu-Natal are more dependent on open water sources than those in Primary Catchment G in the Western Cape. Communities in Catchment U also rely more on alternative water supplies (open water, boreholes and tanks) than those in Catchment G, in which people rely more on municipal tapped water (Statistics South Africa, 2003). The need to reduce the number of people reliant on open water sources is imperative in both catchments as many of the people there are using an unsafe water source and are at risk to changes not only in water quantity, but also in water quality. While rain water tanks and groundwater extraction may be viable options as alternative water sources in Catchment U with its summer rainfall projected to increase (Figures 6.3 and 6.4), this may not be a viable option even to those already using boreholes in Catchment G, as projections show decreases in groundwater recharge under climate change conditions in the central areas of that catchment which again includes Cape Town and its peri-urban areas (Figure 6.9). The above analysis shows that even within Primary Catchment G adaptation options may differ from location to location. It also needs to be noted at this point that with more research into alternative technologies such as rain water harvesting, these may become viable options in one or both of the two catchments.

Overall the Berg-Breede case study area in the winter rainfall region of South Africa was chosen to represent a climate change hotspot with potentially reduced water resources while Primary Catchment U which contains the highly developed Mgeni system could, from a purely hydro-climatic perspective, benefit in future in regard to projected rainfall perturbations. The results, however, show that overall far higher levels of vulnerability could be experienced in the Catchment U than in the Berg-Breede system of Catchment G. This conclusion is based mainly on the higher numbers of inhabitants with low income and education levels as well as higher rural population

densities in the Catchment U. Furthermore, the research showed that often those communities which, on the basis of socio-economic indicators were believed to be least able to adapt, were also those most sensitive and exposed to climate change, partly also due to patterns of urban migration, legacies of past legislation and the urban structure of society. Each catchment presents a different set of challenges to municipal managers, and different adaptation plans will be required. However, through the identification as to which communities are vulnerable to climate change, either because of their exposure, their sensitivity or lack of adaptive capacity (or a combination of these factors), one can provide planners with a starting point on where to focus specific adaptation options and also offer insights into which adaptation strategies may be more viable or less so for a given location. Another important outcome in a planning context is the comparison between vulnerabilities of concentrated (nucleated) versus dispersed communities: For planning and adaptation it is easier if vulnerable communities are spatially concentrated, as is the case in the Berg-Breede study area with, for example, Kayelitsha township. In contrast to this the Mgeni and surrounding catchments of Primary U frequently display highly dispersed vulnerable communities which, furthermore, have rural as well as peri-urban and urban characteristics. The latter calls for a diversification of adaptation strategies, which increases complexities around design, implementation and monitoring.

However, by better understanding different dimensions of vulnerability, earlier action can then be taken than may otherwise have been the case and beneficial trade-offs from climate change could even be gained. Avoiding maladaptation is important nowadays and hence simplistic assumptions in order to reduce the complexities around climate change for decision-makers is not advisable, as this research has shown. Too often we tend to assume, for example, that “regions experiencing high levels of climate change will also be the most vulnerable”, or that “high levels of poverty equal high vulnerability”. If adaptation activities are geared towards enhancing greater safety to society, the environment and the economy, then we need to have a better understanding of the societal characteristics of our communities. This, however, needs to be guided by science and in the case of climate change by scenarios and projections of future climates.

It needs to be noted that the authors have explored some adaptation options in this paper and have identified areas of grave concern, but that politicians, planners, decision-makers and stakeholders will, in the end, need to negotiate what is acceptable to them and viable in financial, societal and political terms. If such processes were to be

informed by relatively objective science such as that developed under this research, more robust knowledge for adaptation design and decision-making could be gained. However, more research will need to be undertaken on the combination and links of societal, economical and biophysical data, as well as on issues of communicating research findings to those negotiating and making decisions in the water sector.

6.7 Acknowledgements

The authors should like to thank the Water Research Commission for funding this research under project K5/1843. Furthermore, our thanks go to the Durban district office of Statistics South Africa and to Brice Gijsbertsen (Geography at the University of KwaZulu-Natal) for making data available and assisting in processing thereof.

6.8 References

ADGER WN (2006) Vulnerability. *Global Environmental Change* **16**, 268-281.

ADGER WN (2001) Scales of Governance and Environmental Justice for Adaptation and Mitigation of Climate Change. *Journal of International Development* **13,** 921–931.

BLENNOW K and PERSSON J (2009) Climate change: Motivation for taking measure to adapt. *Global Environmental Change* **19**, 100-104.

Centers for Disease Control and Prevention (CDC) (2012) Waterborne Diseases. Impacts on Risk. URL: http://www.cdc.gov/climateandhealth/effects/waterborne.htm (Accessed 28 August 2012)

DASGUPTA A and BASCHIERI A (2010) Vulnerability to Cliamte Change in Rural Ghana: Mainstreaming Climate Change in Poverty-Reduction Strategies. *Journal of International Development* **22**, 803–820. DOI: 10.1002/jid.1666

CHAMPION WORKSHOP BERG CATCHMENT (2012) Prioritising adaptation options and identifying responsibilities for implementation, 17 October 2012. The Bell Rosen, Welgemoed, South Africa.

CHAMPION WORKSHOP BERG CATCHMENT (2011) Understanding impacts of climate change on the catchment and designing adaptatiaon options, 18 February 2011. Stellenbosch Lodge, Stellenbosch, South Africa.

CHAMPION WORKSHOP MGENI CATCHMENT (2012) Prioritising adaptation options and identifying responsibilities for implementation, 18 July 2012. University of KwaZulu-Natal, Pietermaritzburg, South Africa.

CHAMPION WORKSHOP MGENI CATCHMENT (2011) Understanding impacts of climate change on the catchment and designing adaptatiaon options, 16 February 2011. Victoria CountryvClub, Pietermaritzburg, South Africa.

FÜSSEL HM (2010) How inequitable is the global distribution of responsibility, capability, and vulnerability to climate change: A comprehensive indicator-based assessment. *Global Environmental Change* **20,** 597–611.

GALLOPÍN GC (2006) Linkages between Vulnerability, Resilience, and Adaptive Capacity. *Global Environmental Change* **16**, 293–303.

GÖRGENS AHM and DE CLERCQ WP (eds.) (2005) *Research on Berg River Water Management.* Summary of Water Quality Information System and Soil Quality Studies. WRC Report No: TT 252/05. Water Research Commission, Pretoria, RSA. 207 pp.

GROTHMANN T and PATT A (2005) Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change* **15**, 199-213.

HINKEL J (2011) Indicators of vulnerability and adaptive capacity': Towards a clarification of the science–policy interface. *Global Environmental Change* **21**, 198–208.

HJERPE M and GLAAS E (2012) Evolving local climate adaptation strategies: incorporating influences of socio–economic stress. *Mitigation and Adaptation Strategies for Global Change* **17** (5) 471-486.

IONESCU CR, KLEIN JT, HINKEL J, KAVI KUMAR KS and KLEIN R (2005) *Towards a Formal Framework of Vulnerability to Climate Change*. FAVAIA Working Paper 1 (NeWater Working Paper, 2). Potsdam Institute for Climate Impact Research, Potsdam, Germany. 20 pp.

IPCC (2007) *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

IPCC (2014) *Climate Change 2014. Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral* Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, USA, 1131pp.

SOLOMON S, QIN D, MANNING M, CHEN Z, MARQUIS M, AVERYT KB, TIGNOR M and MILLER HL (eds.) (2007) *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate*

Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 996 pp.

LUMSDEN TG, KUNZ RP, SCHULZE RE, KNOESEN DM and BARICHIEVY KR (2010) Methods 4: Representation of Grid and Point Scale Regional Climate Change Scenarios for National and Catchment Level Hydrological Impacts Assessments. In: Schulze RE, Hewitson BC, Barichievy KR, Tadross MA, Kunz RP, Horan MJC and Lumsden TG *Methodological Approaches to Assessing Eco-Hydrological Responses to Climate Change in South Africa*. WRC Report 1562/1/10. Water Research Commission, Pretoria, South Africa.

O'BRIEN, K., ERIKSEN, S., SCHJOLDEN, A. and NYGAARD, L. 2004. What's in a word? Conflicting interpretations of vulnerability in climate change research. CICERO Working Paper 2004:04. Olso, Norway. 16 pp.

PLUMMER J and SLAYMAKER T (2007) *Rethinking governance in water services.* Working Paper 284. Overseas Development Institute, London, U.K. 47 pp.

REID P and VOGEL C (2006) Living and responding to multiple stressors in South Africa—Glimpses from KwaZulu-Natal. *Global Environmental Change* **16**, 195–206.

SCHULZE RE (ed) (2012) *A 2011 Perspective on Climate Change and the South African Water Sector*. WRC Report TT 518/12. Water Research Commission, Pretoria, South Africa. 399 pp.

SCHULZE RE, HORAN MJC, KUNZ RP, LUMSDEN TG and KNOESEN DM (2012) The South African Quinary Catchments Database. In*:* Schulze RE (ed). *A 2011 Perspective on Climate Change and the South African Water Sector*. WRC Report TT 518/12. Water Research Commission, Pretoria, South Africa.

SCHULZE RE and HORAN MJC (2010) Methods 1: Delineation of South Africa, Lesotho and Swaziland into Quinary Catchments. In: Schulze RE, Hewitson BC, Barichievy KR, Tadross MA, Kunz RP, Horan MJC and Lumsden TG *Methodological Approaches to Assessing Eco-Hydrological Responses to Climate Change in South Africa*. WRC Report 1562/1/10. Water Research Commission, Pretoria, South Africa.

STATISTICS SOUTH AFRICA (2003) *National Population Census, 2001*. Statistics South Africa, Pretoria, South Africa.

VON STORCH H (2009) On adaptation – a secondary concern? *The European Physical Journal Special Topics* **176**, 13–20. DOI: 10.1140/epjst/e2009-01145-0

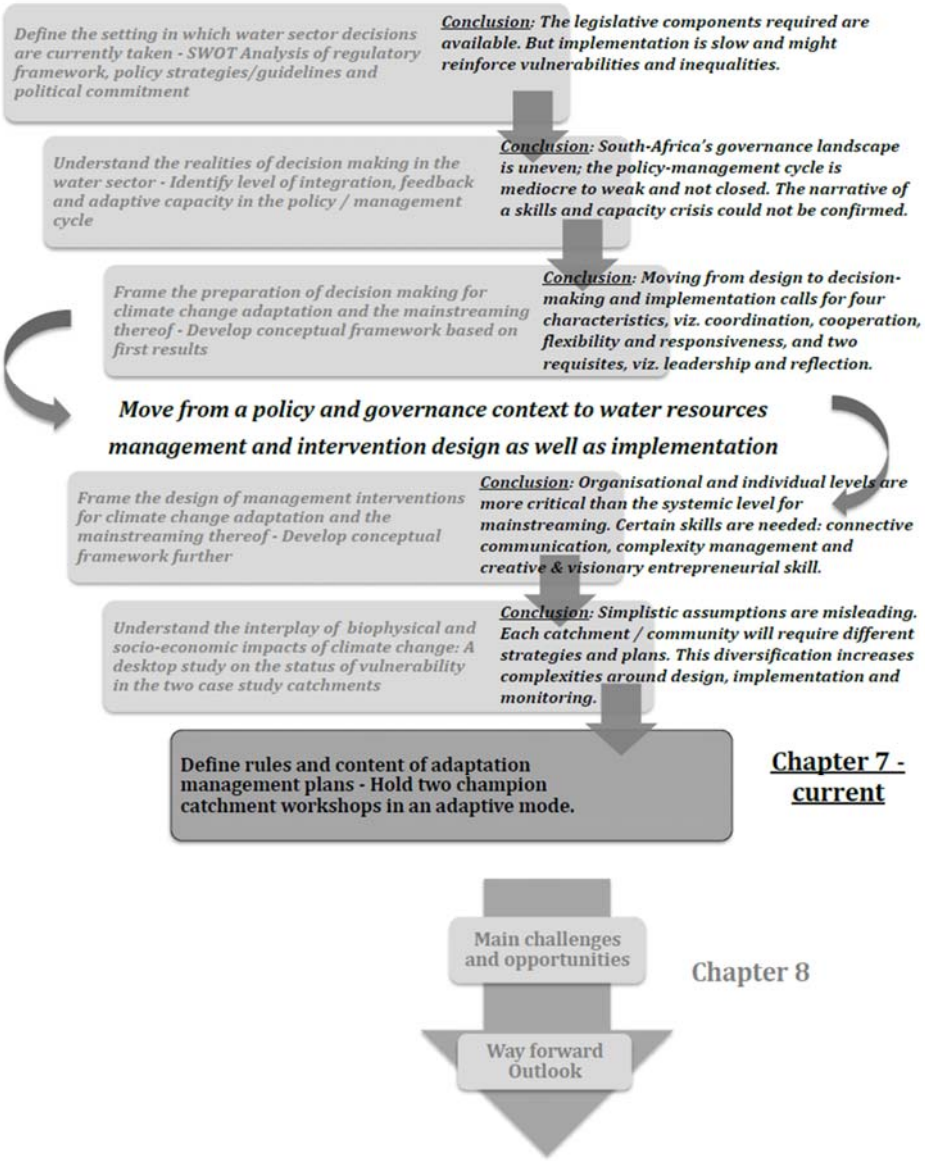
ZIERVOGEL G, BHARWANI S and DOWNING TE (2006) Adapting to climate variability: Pumpkins, people and policy. *Natural Resources Forum* **30**, 294–305.

7. EXPLORING CO-DESIGN OF ADAPTATION TO CLIMATE CHANGE AND PRIORITITSING INTERVENTIONS IN SOUTH AFRICA

S.I.Stuart-Hill[1], N. Methner[2] and T. Lumsden[1]

[1]Centre for Water Resources Research; School of Agriculture, Earth and Environmental Sciences; University of KwaZulu-Natal, Pietermaritzburg, South Africa
[2] Institute of Environmental Systems Research, University of Osnabrück, Germany

At the time of submission of this thesis (March 2015) this chapter was in preparation for submission to the *Journal of Water Policy*. Accordingly the reference list adheres to the rules of the journal.



7.1 Abstract

For South Africa the link between political change, land use change, climate change, economic development and resultant hydrological responses will probably lead to, and exacerbate, a variety of vulnerabilities compared to those experienced in many other regions of the world. Furthermore, the level of uncertainty with regard to impacts of climate change and socio-economic development on the water resources in South African catchments are high. Pre-planning by water management that aims at the availability, development and sustainable use of water resources will be crucial. Thus, a key question is what material and knowledge is needed to further inform policy making, policy implementation and local water management practices within these highly dynamic and change-dominated landscapes of our catchments? Here the concept of spaces for dialogue within two case study catchments has been developed and applied. Furthermore, the concept of champion-driven leadership processes described in Taylor *et al.* (2011) was used to design and run five workshops between 2010 and 2013, three in the Mgeni catchment and two in the Berg catchment, both in South Africa. The aim was to learn together and co-design climate change adaptation options for the specific catchment. The co-design of management interventions for climate change adaptation was based mainly on the champions' and participants' very personal knowledge and experience within their respective catchments and that of their working environment, *viz.* their organisation. Many of the interventions were focused on currently existing stressors as well as on current initiatives and projects. In all cases it became clear that the design of adaptation activities requires considerable time and interaction. Financial support and support of the home organisations of the champions are key pre-requisites in this regard. 'Moments of surprise' in the understanding and learning processes indicate that even experts and water managers cannot simply make assumptions based on what they know, but need to 'dig deeper' and reflect on issues in a participatory way in order to enable informed decision-making. However, it needs to be noted that the long-term evaluations have shown that mainstreaming of climate change adaptation and the related co-designed interventions by the champions into their home organisations was not successful. This suggests that there is a need for further engagement with the champions, and to actually strategize the implementation of the prioritised activities

Key words: climate change, adaptation, water management, co-design, South Africa

7.2 Introduction

Southern Africa is a region known for its high levels of climatic variability as well as of poverty. Furthermore, projections indicate that global warming and impacts of climate change are likely to be well above the global norm and especially above that of most of the developed world (IPCC, 2014). Combined with the other global change drivers, catchments in this region reflect relatively high levels of intensity on all global change issues, now and projected in the future (Ngcobo *et al.*, 2013). The link between political change, climate change, land use change, economic development and hydrological responses will probably lead to, and even exacerbate, a variety of vulnerabilities compared to those in many other regions of the world (Stuart-Hill and Schulze, 2010; Schulze, 2012; IPCC, 2014).

Recent studies for South Africa have shown that currently many land use and other change issues may override the climate change signal in its impacts in certain areas (Ngcobo *et al.*, 2013). When looking at a more distant future set of scenarios under climate change, the joint impacts of land use and climate change are significantly amplified through certain hydrological responses (Warburton and Schulze, 2010). And when taking into consideration that for South Africa a 10 % change in rainfall can result in up to a 20 - 30 % change in runoff (Schulze, 2008), pre-planning the water resources in terms of availability, development and sustainable use will be crucial. At the same time issues of uncertainty surrounding biophysical, societal and economic impacts and feedbacks need to be taken into account (Isendahl *et al.*, 2009; Pahl-Wostl *et al.*, 2011), but in many cases these seem to stop decision-makers from taking action. However, interventions and decisions need to be made. They are indispensable for warding off the continuous degradation of water resources, including severe climate change impacts that might be beyond our capacities to cope and adapt.

Thus, a key question is how we may gain, or at least inform, intervention design and decision-making within an environment of uncertainty and constant change. What material and knowledge is needed to further inform policy making, policy implementation and local water management practices within these highly dynamic and change-dominated landscapes of our catchments? Based on Stuart-Hill and Pahl-Wostl (in preparation, *cf.* Chapter 7) as well as Stuart-Hill and Schulze (2010) three areas of expertise are critical for water management in regard to climate change adaptation design: the knowledge around, respectively, the impacts of change in general and more specifically climate change; an understanding of vulnerabilities and risks which may be

critical at a certain time and in a certain place, and what the resulting design and prioritisation of adaptation activities might be. This type of knowledge and expertise cannot be limited solely to the water sector (Jones, 2011; Ison *et al.*, 2011; Stuart-Hill *et al.*, in preparation), but needs to take place by negotiation within a process of dialogue (Roux *et al.*, 2006; Vogel *et al.*, 2007; Loorbach, 2010). Such a dialogue needs to take relevant policy and day-to-day decision-making of water managers and other critical stakeholders into consideration (Folke *et al.*, 2005; Someshwar, 2008; Inderberg and Eikeland, 2009). Hence, a space is necessary where local and regional knowledge and their needs meet policy guidance and this space should be placed within the 'bigger picture' of water management.

Before such a dialogue can be effected, however, it is important to appreciate that significant challenges exist in regard to South Africa's water management and the wider stakeholder landscape. These include:

(a) Limited capacities (Stuart-Hill and Schulze, in preparation)
    i. of management to act upon, and to take on complex policies and in complex social and physical environments, and
    ii. of the biophysical and social monitoring networks; and
(b) High levels of disparities in our societies (DEAT, 2006; NPC, undated), with
    i. high levels of poverty and malnutrition,
    ii. weak health and educational systems, and
    iii. low levels of social capital in many parts of our societies.

Given the above, the research questions that are explored in this paper are as follows:

(a) How can climate change information be incorporated into the water sector so that it is relevant on a day-to-day basis?
(b) How can adaptation and resulting interventions be negotiated by taking local pressures, needs and knowledge, as well as the national regulatory frameworks and policies, into account?

7.3 Proposing a Space for Dialogue and Negotiation

For clarification of the process envisaged, the analogy of a pressure cooker is used: It receives pressure from the bottom, in this analogy by local authorities and water users, often guided by the regulations from the Water Services Act (RSA, 1997) as well as by local political agendas and issues surrounding livelihoods, which play a major role and, hence, place pressure on the system for delivery. On the other hand there is the cap/lid

of the pressure cooker, representing in this analogy the guidance provided by national policies and laws driven by the National Water Act (RSA, 1998) as well as possible political agendas represented by the national and regional offices of the Department of Water and Sanitation (DWS), with the Minister of the DWS being the custodian of South Africa's water resources (RSA, 1998). Within this pressure cooker a space exists that will potentially be characterised by tension and conflict, high levels of uncertainty, as well as an uneven landscape in regard to knowledge, power and influence related to the co-design of climate change adaptation.

The above implies that leadership will be needed in this space in order to jointly make sense of impacts of climate change on the water resources, and which adaptation options are acceptable in the context of a specific catchment, including the negotiation of trade-offs between decisions taken and interventions implemented. Such leaders will need to bridge the gap between their home-organisation, which may display decisiveness and promote order (Termeer, 2009), and the responsive learning environment of the proposed space for dialogue. Here the concept of champion-driven leadership processes comes into play, as described by Taylor *et al.* (2011), i.e. champions who represent relevant organisations – governmental and private – as well as stakeholder groups that are important in regard to water usage and protection of water resources and, hence, are imperative for sound water management in the catchment. Such leadership, i.e. one which can be referred to as "champion teams", will have to debate adaptation options on a regular basis, i.e. by repetition of meetings, in the proposed space for dialogue (Holling, 2001; Hjerpe and Glaas, 2012), as well as having to incorporate new knowledge and be responsive to short-term and long-term issues of water management (MacKay *et al.*, 2003; Taylor, 2010).

In most of South Africa's Water Management Areas (WMAs) and catchments, Catchment Management Agencies (CMAs) have not yet been established or, alternatively, are not functional yet. However, even in the establishment process they already offer a unique space for contextualising hydrologically related information, for potentially facilitating complex adaptive processes to be realised, for understanding the uncertainties of water and water management, as well as for creating space for innovations (Dent, 2012). As alluded to earlier, negotiations on water management in general, and adaptation to climate change in particular, will have to take place in an appropriate 'space'. The authors chose this space to be the catchment in the South African cases, the reasoning being that it is already the focus of water management based on the existing legal framework and is also supported by the concepts

surrounding Integrated Water Resources Management, IWRM (TEC GWP, 2004). Furthermore, CMAs leave enough flexibility to tailor activities and interventions to specific needs even at a sub-catchment scale. However, barriers specific to the catchment and the wider spatial area in which they are situated, as well as administrative boundaries that do not coincide with the catchment boundaries, have to be taken into account (Pahl-Wostl *et al.*, 2007; Huntjens *et al.*, 2012). Within such a space of dialogue the co-design of adaptation and related interventions should be more authentic/valid and implementable (see also Folke *et al.*, 2005). Furthermore, based on the new knowledge gained during the dialogue (i.e. the social learning process), innovations on water governance and with regard to intervention design specifically are highly probable (Woodhill, 2010) and may create a window of opportunity to mainstream adaptation into the participants' daily work. Therefore, it is suggested to open a space of dialogue in collaboration with all water users and design an inclusive process that embraces both top-down and bottom-up practices. The representation of the water users in the process does not need to be achieved by a designed network of champions, as was done in the case of this paper, but could be achieved by a community of practice that has emerged, for example, through self-organisation or by existing organisations such as Catchment Management Fora[1].

A network of champions in this context is a group of influential decision-makers from relevant organisations as well as water users and stakeholder groups from within a WMA or catchment. These champions need to meet in the catchment, thereby forming a space for dialogue. This concept is also based on the idea of Transition Arenas as, for example, Loorbach (2007 and 2010) has developed. Within these spaces for dialogue the champions communicate knowledge, needs and interests, aiming at negotiating outcomes and strategies that are based on their local knowledge, with a focus on livelihoods and already existing vulnerabilities. It is envisaged that such champions have an internal dimension which represents their specific knowledge of the catchment and capacity for critical thinking, as well as an external dimension which is characterised by their leadership ability, institutional memory and communicative skills, as a result of which this enables them to act as agents of change in their home organisation (Loorbach, 2010).

[1] CMFs are non-statutory bodies. Their main purpose is "to develop a trusting and constructive relationship between all the stakeholders and interest groups and to find a common vision." They "have been found to play a key role in terms of participation and representation" (de la Harpe *et al.*, undated).

It needs to be noted here that it seems critical for any process of implementation to have clear definitions of leadership, responsibilities, appropriate designs of communication plans and rules of negotiation (Mostert *et al.*, 2007; Pahl-Wostl *et al.*, 2007). This is especially the case for integrative and adaptive management approaches such as the one to be initiated here: In order to perform in an environment of change such a dialogue needs to be undertaken on a regular basis and include times for evaluation and of consolidation (Kotter and Rathgeber, 2005; Stuart-Hill *et al.*, in preparation). Hence, it is suggested by the authors that if such a process were to be incorporated into decision-making, then a detailed communication strategy as well as modules to build capacity would need to be included in the long-term (Pahl-Wostl, 2007; Sherwill *et al.*, 2007), for example through different forms of capacity building and social learning. This would ensure that needs and viewpoints of the different participants would be understood and, in the end, such an approach would sum up to a holistic strategy with implementable interventions.

7.4 Methodology

The aim of the research presented in this paper is to discuss the level of the individual decision-maker within the water governance system of South Africa. Hence, the work focusses on the management environment which frames the decision-maker's ability to design adaptation and resulting management interventions. This is done by a process (*viz.* workshops, see below) that offers the opportunity to co-design adaptation plans with the wider water community (*viz.* champions, see below), guided by understanding the unique set-up of the relevant catchment and, therefore, an understanding of the local vulnerabilities of its biophysical as well as social-ecological systems. Furthermore, the process should enable the champions who are part of the process (internal dimension) to demonstrate leadership within their home organisation (external dimension) on implementing the co-designed adaptation interventions. Here the internal dimension on the one hand is understood as the champion bringing personal as well as organisational knowledge into the co-design process; on the other hand the external dimension of the champion is reflected by the process of feeding the new knowledge gained from the social learning processes into their home organisation, thereby creating opportunities for implementation and potentially innovative approaches. If the latter is possible, it is likely that this will lead to the mainstreaming of climate change into the wider water sector and potentially beyond it.

Ensuring the consistency and overall sustainability of such a process will need regular repetition (Holling, 2001; Hjerpe and Glaas, 2012) as well as facilities for evaluation and monitoring of the designed interventions and their successful implementation. Furthermore, it will need a shared commitment for collective action (Folke, *et al.*, 2005) if the interventions negotiated are to be sustained beyond the process itself and the workshops held.

7.4.1 Case studies

Two South African case studies have been chosen to explore the options and potential scope for such a designed process, with these being climatically and socio-economically divergent catchments. One is the Berg catchment in the Western Cape province (in the southwesterly part of South Africa) in the winter rainfall region, while the other is the Mgeni catchment in the province of KwaZulu-Natal (in the eastern part of the country) representing a summer rainfall region. Both have a significant climate change signal in the current projections, with the Western Cape projected to experience decreases in rainfall and corresponding runoff and the Mgeni projected to have increases in rainfall and runoff (Schulze, 2012). Furthermore, "the [Mgeni] catchment is made up of a mix of land uses, including urban settlements, rural areas, subsistence and commercial farming as well as various open spaces and degraded areas" (Stuart-Hill and Schulze, accepted for publication). Much of the Mgeni catchment area is rural with many poverty stricken communities. "The [Berg] catchment consists of a mixture of land uses, including urban settlements, rural areas, subsistence and commercial farming (dryland wheat and mainly irrigated export-orientated high value deciduous fruit products), as well as various open spaces and degraded areas" (Stuart-Hill and Schulze, accepted for publication). Good contacts existed between the authors and the relevant decision-makers and stakeholders in both catchments before the workshops were held. This was assumed to be a sound starting point for a trustworthy and open relationship, creating a 'safe' and constructive environment needed for the workshops.

7.4.2 Champion workshops

The champions identified in both catchments were drawn from existing communities of practice and represented varied expertise in that they came from different organisations, authorities and stakeholder groups. A fair representation of major organisations involved in the management of the specific catchment areas was ensured with the assistance of the respective regional offices of the Department of Water Affairs.

Furthermore, the participants had been previously identified as ‘champions’, i.e. they were leaders and experts in their respective spheres of influence, they had a good understanding of the catchment area, were critical thinkers and possessed the required institutional memory to provide valuable inputs to the discussions. All of these are critical attributes for ensuring the understanding of issues at hand, the appropriate design of interventions and their respective successful implementation (Pahl-Wostl and Rettig, 2010; Personal communication).

Based on South Africa’s legal framework and the concept of CMAs respectively (*cf.* Section 7.2) the catchment was chosen as the appropriate spatial scale for the champion workshops and two sets of workshops were held in both catchments; the first in the beginning of 2011, the second in mid-2012. The aim was to accommodate not more than 10-15 participants in order to avoid the group from splitting into sub-groups in the course of the discussions. Another more technical workshop in the Mgeni catchment was held in the beginning of 2013 which included some of the Mgeni champions, but also a wider range of other stakeholders.

The first set of champion workshops (*cf.* Table 7.1) aimed at creating a joint understanding of the catchment and its hydrological as well as biophysical processes and socio-economic characteristics. A group model building exercise was used to achieve this. Furthermore, the champions were introduced to the latest scientific findings on climate change and its impacts on the respective catchments as well as resulting projections of vulnerabilities. Based on this knowledge, the champions then explored strategies for adapting to climate change in the catchment, and co-designed adaptation strategies, including options for improving decision-making and strengthening water management institutions.

Table 7.1 Scope of the first set of champion workshops

Sessions	Content	Envisaged Outcomes
1. Creation of a joint catchment model	Major factors that impact water availability in the catchment area and important feedback loops	Understanding the functioning of the catchment area and its water users
2. Mapping of sensitive areas and water dependent activities	Mapping of sensitive areas (from upper to lower end of the catchment)	Identification of areas of concern and their causes
3. Overview of the latest scientific findings of potential Climate Change impacts in the catchment areas	<u>Projections for the Mgeni:</u> • Higher risks of flooding • Increase in runoff because of more rainfall events • Higher evaporation rates <u>Projections for the Berg:</u> • Less rainfall during winter months • Drier and hotter • Higher evaporation rates	Climate change beyond the 'black box'
4. Re-assessment of the catchment model through a climate change lens	• Potential impacts • Needs	Future threats and existing obstacles
5. Exploring adaptation options	Adaptation strategies	Identification of priorities, and potential obstacles

The second series of workshops (*cf.* Table. 7.2) set out to establish other options for knowledge creation, communication and consolidating the safe and constructive environment crucial for the process *per se*, as well as the external dimension (i.e. the process of feeding the new knowledge gained from the social learning processes into their home organisation) of the champions alluded to earlier. Furthermore, it aimed at exploring the potential for mainstreaming climate change adaptation in a governance system that is presently neither fully functional nor has existing policies being implemented and, additionally, is not always accompanied by management tailored to the specific challenges the catchment faces (Stuart-Hill and Schulze, in preparation).

Table 7.2 Scope of the second set of champion workshops

Sessions	Content	Envisaged Outcomes
1. Discussion on "A 2011 perspective on climate change and South African water sector" (i.e. the South African Climate Change "Atlas")	Gaining insight if the content of the so-called Atlas is relevant for the champions' work and decision-making, and clarify who would / should do the knowledge brokering of scientific outcomes contained in the Atlas	Refresh and update knowledge on climate change impacts for South Africa as well as the catchment. Recommendations for further communication and distribution of such knowledge.
2. Re-assessing the catchment map of sensitive areas and water dependent activities	Have sensitive areas and their priorities changed in the past year? If so, why?	A to-do-list of actions and prioritisation of these
3. Implementing the "Needs" and "Adaptation Options" lists from 1st workshop	Identify who is responsible for the implementation of each idea / option	A sense of what has to be done and what can be done by each champion when back in their home organisation

In the Mgeni catchment one additional workshop with a more technical focus of the actors was held in early 2013. This workshop originated from a 3-year research project titled "Projected Impact of Climate Change on Water Quantity and Quality in the Mgeni Catchment" and was aimed at assessing the capacity of the regional bulk water supplier (Umgeni Water) and other key decision-makers (mainly government) to adapt to projected impacts of climate change. As was the case with the other two Mgeni catchment workshops, the participants were key players in the management of the catchment's water resources and during the workshop they co-designed adaptation options and strategies. In regard to the latter task, the workshop was split into two main narratives of projected climate change, i.e. highly probable changes in the future and less certain changes in the future. Both narratives were introduced by experts on the latest scientific findings and these were then discussed in breakaway groups by considering what impacts may be expected, their severity and possible adaptation actions. The breakaway groups that were formed for the discussions focussed on:

(a) resource water quality, treatment, health and sanitation,
(b) storm water management, safety and disaster management,
(c) water quantity and demand, infrastructure and distribution, and
(d) ecosystem goods and services.

Back in plenary, the groups presented their outcomes and the final findings for each narrative relevant for each breakaway group were discussed.

7.4.3 Group model building (GMB)

Group model building (GMB) was used in the first two champion workshops with the aim of levelling the knowledge landscape of the champions, and also to ensure a participative atmosphere for the workshop. The use of GMB to create a common understanding of a specific situation is particularly relevant for the water sector as water resource management at the catchment level is a very complex process (Vennix, 1999) involving a variety of organisations operating at different scales with different knowledge levels and understanding of the catchment area and the water resources therein. Hence, in this type of environment it becomes crucial to first create a common basis of engagement among the participants who have quite different relations to the catchment, before any key drivers and other major issues can be identified.

GMB is an interactive learning tool through which the participants share with each other their knowledge (scientific and experiential) as well as learn about each other's needs and priorities. Vennix (1996, p 5) identifies five major goals of GM, *viz.* learning about a so-called 'messy' problem, team learning, shared understanding, fostering consensus (also on solutions) and commitment linked to its implementation.

By this process the multiple realities created by the individual decision-makers, represented here by the catchment champions, can be revealed by interpreting situations which then result in different mental models (Vennix, 1999). The model building exercise then becomes the opportunity to create a comprehensive overview of the existing mental models (Vennix, 1996). The scientist, rather than being the sole knowledge provider, takes on the role of a mediator who ensures that the discussions continue to be focused on the main subject area. Overall, it has been proven that GMB can be a very powerful learning tool (Pahl-Wostl and Hare, 2004) which not only stimulates the existing expertise of the participants, but also allows for the establishment of a more holistic picture of the catchment and its functioning.

7.4.4 Open discussions and co-design

All other sessions of the workshops were run as open discussions during which the facilitator ensured that all present were given a fair opportunity to speak and bring

across their point of view. In particular, when co-design activities were in process, the facilitator ensured that insight was obtained from each champion. In all the workshops held the majority of champions had been working together, or at least had known each other already, from previous interactions.

7.4.5 Evaluations

Short questionnaires were designed in order to evaluate the outcomes of the workshops on the day (see Section 7.9 and 7.10). Furthermore, follow-up questionnaires were sent out a few months later to all champions present at the first set of workshops held (see Section 7.10). The first evaluation was to verify the relevance and usefulness of the actual activities carried out during the workshop, the latter to gain insight into the potential mainstreaming of knowledge into the champions' decision-making environment within their home organisations. For the second set of workshops an evaluation was not undertaken because of its character of an extension of the first set of workshops held. For the technical Mgeni workshop an immediate evaluation was carried out as was a follow-up evaluation a few months later.

7.5 Results

This section reflects on the results gained from each workshop. Much of the material produced by the participants is not presented here, owing to limited space. However, the authors have focussed on key results in order to answer the research questions posed in the introduction of this paper. Further results can be found in Annexes 3-6 (*cf.* Section 7.11).

7.5.1 First set of workshops

The first two champion workshops in the Mgeni and Berg catchment were successful, gauged by the good attendance and more time spent at the workshop by the champions than had originally been planned. Positive evaluations were also received from the participants.

Mgeni

The first Mgeni workshop took place in mid-February 2011 and was attended by 9 participants.

The Group Model showed two key aspects identified by the group which influence water availability in the catchment. These were “Demand” and “Pollution” and they were strongly influenced by other issues, mainly the many interlinkages and connections between these issues. Interestingly, ‘stream flow reduction activities’ (i.e. levies imposed on commercial production forestry based on the additional water the forests use in relation to the natural vegetation they replace), as conceptualised in the National Water Act of 1998 and the presence of large storage ‘dams’ were placed amongst the natural hydrological variables. It became quite clear that besides climatic factors, land use practices, urbanisation, the expansion of alien invasive vegetation, the state and operation of existing infrastructures (e.g. waste water treatment plants) and point as well as non-point pollution all strongly influence the water availability in the catchment. Major emphasis in the discussion was placed on the poor state of existing infrastructure, the impact of streamflow reducing activities and the current wastage and pollution of existing water resources. It was pointed out that the ecological reserve determination (the ecological reserve is the amount of water ‘set aside’ to protect water ecosystems and sustain healthy ecosystems) had not been finalised yet for the catchment and that once this was done, it was expected to further impact negatively on the water availability for human utilisation in the Mgeni catchment. Current urbanisation trends and population growth were also drivers that would impact water availability in the Mgeni catchment. Overall, the modelling exercise helped the participants to understand the non-linear feedback loops between the different factors of the water system impacting on the hydrological response and also provided some common understanding in preparations for the scientific presentation on climatic and hydrological trends under climate change in South Africa, and more specifically in the Mgeni catchment, which followed.

The exercise of mapping sensitive areas within the catchment was of great value for all attendees (non-scientists and scientists alike) as it really allowed the location of important vulnerability hotspots in the catchment to be identified and associated causes to be highlighted. Interestingly, the majority of vulnerable areas were identified along the main river stem, but also reaching far into the catchment’s hinterland, emphasising the relevance of the overall catchment.

The mapping exercise was followed by a scientific presentation on the latest climate change research findings for the catchment. The participants appreciated the time given for clarification and for learning, based on this ‘new knowledge’ presented.

In the session that followed the participants agreed with a high level of consensus on the envisaged impacts for the catchment. Also, a list of needs for successful adaptation was collated with minimal effort, while the list of adaptation options and strategies required more time and intense discussion. However, at no time was there any real conflict arising among the champions. In summary, the champions came to the conclusion that if existing institutional and infrastructural challenges were not addressed adequately, climate change would amplify existing threats. This was particularly true when it came to pollution of the catchment's water resources and to disaster risk management, as current projections seemed to indicate an intensification in local and regional flooding in the Mgeni catchment due to increased heavy rainfall.

Berg

The first Berg workshop also took place in mid-February 2011 and was attended by 16 participants. The number was slightly challenging for facilitation and it was difficult to motivate each champion to voice an opinion on each issue raised.

The Group Model that was created shows a very differentiated and detailed picture on the issues of water storage, both natural and in dams, within the catchment. Again, the water demand issue was very central and it had several interlinkages pointing towards the main card of water availability. Furthermore, urbanisation and household water use were discussed in detail, also reflecting on future water demand and the overall issue of assurance of the supply in the province. The same applied to effluent problems, which is mostly linked to problems associated with dysfunctional waste water treatment works. As was the case in the Mgeni workshop, the Berg catchment participants quickly realised that several different factors and drivers influence water availability in the catchment. Some of the participants pointed out that water availability in the upper catchment was determined by different factors than in the lower catchment [e.g. quantity versus quality, agriculture versus urbanisation]. Given that issues of the generally poor water quality were of great concern in the Berg catchment, quite considerable emphasis was placed on how pollution and also alien invasive vegetation impact on water availability and the catchment's water balance. The discussion revealed that in-migration, in particular the steady and uncontrolled influx of people from low income brackets and from outside of the province, places enormous stress on the catchment's water resources. However, this risk factor was seen to be given little attention at higher decision-making levels.

When mapping the hydrological sensitive areas within the catchment, most of the hotspots which were identified were linked to either pollution caused by the poor management of waste water treatment plants and associated infrastructure, to urban areas along the river where waste from formal and informal settlements is directed into storm water systems, or to the spread and threat of both terrestrial and aquatic alien vegetation. Illegal activities in some sub-catchment areas and non-sustainable agricultural land use practices also added to the problem of degrading water quality. Here it needs to be noted that commercial agriculture, and especially the fruit export sector, plays a major role in the Berg catchment in regard to income and employment.

This was, as in the Mgeni workshop, followed by a scientific presentation on the most recent climate change research findings for the catchment. The participants again appreciated the time given for clarification and, learning based on this ‘new knowledge’ presented.

The discussion which followed was lively and some moments of conflict arose especially around the co-design of adaptation options and strategies. However, in the end all champions agreed on a list of impacts, needs and adaptation options. In conclusion, the fruit export sector was identified as being highly threatened by degrading water quality, as especially European Union quality standards of the fruit products could not be met when irrigation and processing was with poor quality water. However, what seemed to be alarming was that the true extent of pollution levels in the Berg catchment could not actually be determined as current hotspots had been identified based on historic data and sampling sites without taking into consideration all major pollutants. Consequently, a poor understanding of the real risks exists at all decision-making levels.

7.5.2 Evaluation of first set of workshops

For both workshops the champions felt comfortable in regard to the atmosphere in the workshop and all agreed on the fair and transparent dialogues that were possible between the participants. Furthermore, they agreed strongly that the participants presented a balanced and comprehensive mix of interests and role players in water resources management of the catchment.

Mgeni

Directly after the Mgeni workshop, 8 of the Mgeni champions filled out an evaluation form: The GMB exercise was rated at between 6 and 10 out of 10, with a very good average of 7.6. All answers elaborated on the usefulness of getting to know different views and ideas. However, four of the champions saw this approach as being of limited applicability on a day-to-day basis for decision-making (no further reasoning for this was provided by the champions), while three of the champions rated it useful as long as it was used in a structured workshop set-up. The usefulness for strategic and longer-term planning was emphasised numerous times. Generally, it was considered useful to gain a more holistic picture, to understand impacts and to appreciate cumulative consequences especially in terms of climate change. However, it was also highlighted by two champions that the GMB should be an open model, that is to say that over time more information and knowledge should be added, as well as bringing the model into some type of public participatory forum for discussion and adjustment. Five out of the 8 evaluations (63%) answered that they gained new knowledge and insights, while the other three already had the knowledge that was presented.

Two champions rated the mapping of sensitive areas most useful, while two others appreciated especially the scientific expert presentation on climate change. The other four focused on the benefits of the GMB exercise. None of the evaluations suggested any conflicting issues or negative aspects within the group, the working atmosphere or the exercises undertaken.

In early June 2012 a communication was sent out requesting a follow-up evaluation of the workshop. Only five answers were received out of a possible 19, even after sending out two reminders which emphasised the high relevance and urgency of their response for good scientific outcomes. In hindsight, all respondents still found the workshop to have been useful. They all formulated very concrete ideas on the additional information needed for their working environment, and also highlighted cumulative and secondary impacts of climate change in this section. However, no longer-term impact of the workshop on their decision-making or patterns of thinking could be established, although one respondent elaborated on how his ability to consider impacts of decisions on water availability and the effects of climate change on the overall catchment, had improved. There was no indication of any knowledge or initiatives being taken by the champions to their home organisations (the external dimension). Interestingly, all participants indicated they would like to be kept informed and even requested annual workshops like the one held. Overall, the long-term impacts have not been as beneficial

as expected, but the evaluation still was positive and gave a good grounding for the second workshop in 2012.

Berg

In contrast, the Berg workshop was only evaluated by 5 of the 16 champions present. None of the others approached via email responded: All five rated the workshop between 8 and 10 out of 10 and thus giving it a very good average score of 8.8. However, it must be noted that one champion left the workshop early towards the end of the GMB exercise as she did not see the usefulness of the workshop and thought it was a waste of time. The champion also did not fill out an evaluation form. The positives of GMB for decision-making were seen mainly in the holistic approach it presented when making local decisions, the usefulness of triggering strategic thinking, and that the results could be communicated to the wider water community. The main benefit was seen in identifying gaps and highlighting important aspects for adaptation. Interestingly, most of the respondents elaborated somewhere in the questionnaire on the potential to use GMB for enhancing communication and even to establish it as a management tool for communication and strategic planning.

Again the other exercises, i.e. mapping of sensitive areas and the scientific expert presentation, were also rated as highly beneficial and informative.

For the Berg catchment participants an email was also sent out in early June 2012 requesting a follow-up evaluation of the workshop. Only three answers were received, even after sending out two reminders emphasising the high relevance and urgency for sound scientific outcomes. Again the respondents valued the information they gained at the workshop and also had very concrete ideas of what additional information they would need. For two respondents, even longer-term impacts could be established as their decision-making and patterns of thinking had been influenced, but both highlighted at the same time that they would need more detailed information to consider climate change impacts in their inclusive decision-making. There was no indication of any knowledge or initiatives being taken by the champions to their home organisation, i.e. the potential influences of the external dimension were not accomplished. However, all indicating that they would like to be kept informed on issues of climate change and emerging vulnerabilities.

7.5.3 Second set of workshops

The second set of champion workshops in the Mgeni and Berg catchment were both successful in their outcomes, but had a lower attendance than the first. In the Berg only few of the former champions attended, but numerous other participants joined and contributed to the discussions. Those present engaged well in the discussion and again spent more time at the workshop than was originally planned. The evaluation of both workshops was difficult, having received limited feedback (see Section 7.4.4). It could not be clarified what the reasons were for this.

Prior to the workshop the champions were offered a preliminary print-out of the updated climate change atlas for South Africa ("A 2011 Perspective on Climate Change and the South African Water Sector"). Therefore, part of the workshop was spent on reflecting on the relevance and 'translation' of such scientific information.

Mgeni

The second Mgeni champion workshop was held mid-July 2012. Seven champions participated, of whome 5 had attended the first workshop.

The feedback session on the updated climate change atlas created a lively discussion. The section on uncertainty issues and the related discussion was highlighted as very useful, as the issues surrounding uncertainty were spoken about openly and handled by using a 'confidence', as against 'uncertainty' approach. The champions emphasised that impacts on infrastructure need to be incorporated into the issues of climate change and also impacts on water supply; furthermore, it was suggested to use Environmental Impact Assessments as a tool to mainstreaming climate change more into decision-making. It was noted that representation from agriculture was missing on the day and that none of the participants knew who the appropriate champion should be. Communication was identified as a key issue and was seen as entirely lacking in the Mgeni catchment. This was also seen as the reason for the absence of a common / unified catchment management approach. The opportunity of a future Catchment Management Agency as a new and supportive structure for communication was negated as its implementation was too far into the future and because it would have a more provincial level dimension, and hence would be too diffuse for localised relevance. Rather a Catchment Management Committee specific to the Mgeni catchment was called for by the champions, although no one was sure how to take this forward. The regional office of the Department of Water Affairs (now Department of Water and

Sanitation) was seen as not being interested in, nor supportive of, such an initiative. Another major weakness and threat was once again the identification of the missing environmental reserve determination for the catchment, as already discussed in the first workshop (*cf.* 7.5.1). If implemented, the Reserve would reduce the amount of water available for authorised usage and thus would be seen as to exacerbating water scarcity, especially under climate change.

The review of the sensitive areas showed that the challenging issues for water management in the Mgeni catchment were still the same as in the first workshop. The only changes made was to add the Mkomazi catchment (an under-utilized catchment located adjacent to and south of the Mgeni) to supplement the Mgeni's water resources and water from Springrove Dam (on the Mooi River north of the Mgeni, and under construction at the time of the workshops), as well as including upgrades to/repairs to aging infrastructure, which would need vast injections of capital; with the latter found to be relevant for the entire catchment with no specific area identified. The discussion on how to prioritise the areas of concern reflected typical interests by the organisations which the champions represented: the NGO, for example, wished to focus on the tributaries, the municipalities referred to dams, sewage works and informal settlements as crucial to deal with first, and the bulk water supplier saw Midmar Dam as the starting point for the assurance of water supply from the catchment. However, after having raised their preferences the champions agreed swiftly on a source-to-sea approach, starting with the upper tributaries and the major wetland (Umgeni Vlei) in the headwaters of the Mgeni and then working down the main stem of the Mgeni to its estuary into the Indian ocean.

In contrast, the discussions on responsibilities for the 'needs' and 'adaption options list', were difficult and slow to come to a consensus: For the 'needs' the responsibilities which were identified were very general, ranging from improved science, better cooperation with governmental departments on all levels, to the role of NGOs. Nevertheless, the special roles of the Department of Water Affairs (DWA, now DWS), the Department of Environmental Affairs (DEA) and the Department of Agriculture, Forestry and Fisheries (DAFF) on a national level was stressed. In regard to the 'adaptation options' the responsibilities identified were far more concrete. Key actors and initiators were DWA, DEA (including the provincial department) and municipalities; with at least one of them having been mentioned in each of the 15 strategies which the respondents listed, often in some kind of combination. DWA was,

in two cases, identified as the sole responsible agent and was seen to play a crucial role in 8 of the 15 strategies suggested.

Berg

The second Berg champion workshop was held mid-October 2012. Of the 12 participants only two had been at the first workshop. However, all participants felt comfortable and agreed with the outcomes and suggestions made in the first workshop.

The discussion on the Atlas of Climate Change and the South African Water Sector revolved mainly around the interplay of land use and climate change. The discussions moved on to the relevance of climate change for actual water management. All champions agreed on the need to make use of additional observations such as those from citizens and especially farmers in order to obtain a better and more detailed picture for the catchment. Identified as being particularly relevant for the Berg catchment were high rates of evaporation (especially in the context of irrigation water demands), changing water use licences (including those for water re-use and having flexibility in regard to water requirements in different seasons and availability), issues on land management and land use (e.g. removal of aliens, restoration of wetlands, reducing pollution and holding users accountable for deterioration of the resource), the effects of fires in the fynbos vegetation and the rapid population growth; the latter being mainly linked to water quality issues. However, at the end of this activity all champions questioned whether solving all of the aforementioned issues would actually delay the need for climate change adaptation.

In the discussion on the sensitive areas within the catchment all participants agreed unhesitatingly on the starting point of actions in the catchment, this being the upper reaches and wider catchment of the Berg. Yet, prioritising this would call for further finances and strengthening of institutional arrangements, i.e. a CMA and a so-called water safety plan. The next priority was to be non-point source pollution in the catchment, especially from over-irrigating by farmers. From there they suggested moving to the issues of new settlements, both formal and informal, as well as the general impacts of urbanisation. Last, but not least, the champions would tackle unlawful water use and water use management in general.

In regard to the responsibilities to tackle the needs list and implement the adaptation options list, a strong focus was placed on national government as the custodian of South Africa’s water resources on the one hand, while on the other the land owners were

highlighted as key actors in the catchment. For the needs list DWA, the CMA and the municipalities were found to be key actors in the Berg. In regard to the adaptation options, land owners and farmers were, additionally, identified as key players. Further to that, scientific advancement and the the role of the Water Research Commission in funding relevant research were seen to be of great relevance in tackling the challenges of adaptation and informed decision-making in this catchment. In summing up this session, the champions identified a Catchment Management Strategy as being crucial to moving towards general successful river basin management.

7.5.5 Additional Mgeni workshop

As mentioned previously, a more technical workshop on designing adaptation was held in the Mgeni catchment in January 2013 and was used for further insight into learning about climate change, adaptation planning and prioritising activities. The workshop drew 27 participants, of whom three were champions of the previous Mgeni workshops. The lead author's role was that of an observer and an evaluator.

As in the two champion workshops held previously, a scientific presentation by an expert opened the workshop activities. This was meant to encourage the discussion on climate change impacts and the co-design of adaptation activities. Interestingly, no questions were asked or comments made after the expert presentation. The workshop activities unfolded in four breakaway groups, *viz.*

(a) Resource water quality, treatment, health and sanitation;
(b) Storm water management, safety and disaster management;
(c) Water quantity and demand, infrastructure and distribution; and
(d) Ecosystem value.

The breakaway groups were very different in the composition of their members as well as in the nature of their discussions. The latter refers specifically to one or two dominating participants, but in all groups' power relations and conflict evened out towards the end of the session. The two bigger groups ('Resource water quality, treatment, health and sanitation' and 'Storm water management, safety and disaster management') quickly had one of its members nominated as facilitator in order to structure the discussion. Infrastructure played a key part in most of the discussions and in the design of adaptation activities.

Convening back in plenary the aim was to gain consensus on all adaptation activities designed. The participants stressed the need to factor climate changes into the national plan developed for the future by the National Planning Commission of South Africa as well as into the Presidential Outcomes (i.e. South Africa's Office of the President has defined 12 key outcomes for the electoral period of 2014 to 2019; these have been approved by cabinet and based on these the President signs performance agreements with all Cabinet Ministers). Improved land use and town planning were highlighted by most of the groups, but in order for this to be effective there was an urgent need identified for integrated spatial planning across scales. The continued trend of immigration and urbanisation was likely to see more people moving into vulnerable zones in urban areas and also flood plains within the catchment. The need to also work with traditional leaders in developing / implementing climate change adaptation plans was stressed, as the influence of rural communities in catchment areas and on water supplies is significant in the Mgeni. The value of the Working for Water programme in clearing alien invasive species and thereby releasing more water from catchments was emphasised. Dam safety was identified as an issue to be re-evaluated going into the future in order to ensure that original designs (and proposed modifications to increase storage) would still be appropriate.

In the afternoon session, the breakaway groups discussed the less probable changes. A significant challenge was that three different potential climate change narratives had to be assessed, these being a very wet, wet and very dry storyline. Therefore, the discussions evolved more around sense making of the storylines and, as a result, assumptions had to be made by the participants in order to be able to co-design actual strategies to adapt to climate change. This, together with time constraints and fatigue, led to non-responses in the assessment sheets, especially regarding the severity rating of climate change impacts and adaptation options.

With participants leaving, the wrap-up session to complete the workshop only had 16 participants remaining. In the wrap-up session it became clear that the main issues identified under climate change for the Mgeni were the cumulative impacts of small farm dams in the catchment, the key role of infrastructure, the importance of water quality, as well as the functioning of landscapes and the rivers with integrity. Last, but not least, technology was highlighted as being a very important aspect that needs to be included in adaptation, but caution was to be exercised not to use it as a panacea for solving all the existing water challenges. Furthermore, the very dry and very wet storylines would be costly to deal with while the wet storyline would be more

favourable in terms of financial implications. More details on the key points highlighted from the day's discussions include:

(a) Numerous impacts and actions were identified. Some actions would be difficult to implement while others are very achievable.
(b) Infrastructure is going to be important. It will need to be well maintained and designers of new infrastructure should be kept abreast of developments in the understanding of likely climate change impacts.
(c) The outlook for water quality is not good owing to projected increases in flow variability. This would result in deteriorating water quality associated with more very wet (associated with greater wash-off of pollutants) or very dry (less dilution capacity) conditions.
(d) The role of functioning ecosystems, particularly those containing wetlands, in offsetting negative impacts of climate change would be important. Every effort should be made to maintain these ecosystems.
(e) Technology was highlighted a number of times as a means of overcoming some of the challenges associated with climate change and is likely to be an important adaptation measure in the Mgeni catchment.

Other aspects that did not fit into the desired categories, but which were found to be of importance for adaptation in the Mgeni were placed on hold. These related mainly to

(a) society and politics, including the role of traditional systems,
(b) flexibility in adaptation planning itself,
(c) agriculture and its roles in regard to food security and biofuels,
(d) the question as to whether we were building and maintaining our human capital,
(e) appropriate packaging of the climate change message, and
(f) the risk of mal-adaptation.

Evaluation

Directly after the workshop the 16 remaining participants filled in the evaluation form: all of the participants rated the level of awareness on climate change impacts and the need for adaptation at 5 and higher out of a possible 10. Those who already had climate change knowledge rated this at 5 or 6, all others rated it up to 9. On average a rating of 6,9 was reflected. All of the respondents, except one, would like to have further exchange on the topic of climate change, its impacts and vulnerabilities. The type of knowledge gained was – not surprisingly – mainly on direct impacts of climate change. Therefore, knowledge gaps identified related to other sectors which were beyond the biophysical impacts (only temperature and the feed forwards were mentioned by two

respondents) and were all of a more complex nature, such as integrated planning (cumulative effects of impacts and adaptation), political interventions, long term financial planning (business sustainability), immediate impact mitigation, infrastructure impacts (including ecological infrastructure), governance and regulation aspects, adaptation of organisations, communication, the inclusion of traditional leaders and/or sector vulnerability.

One question in the questionnaire related to specific needs in order to foster informed decision-making under climate change: 19 % of the respondents highlighted that the certainty level of the likely impacts would need to be improved; other biophysical issues stressed were seasonal variations in temperature, and an overall need for more quantitative information for decision-making. All other issues which were highlighted related not to biophysical aspects of climate change, but rather to higher order level impacts such as catchment management, infrastructure planning, the socio-economic dimension of adaptation and its implementation, more appropriate packaging of climate change information and especially the capacity for implementation and enforcement partnered with political and institutional will.

Requesting a follow-up evaluation had limited response. Only 5 filled in questionnaires after two reminders: The answers indicated that only the decision-making of two of the five respondents had been influenced by the knowledge gained, and two respondents' perceptions for daily-decision-making had changed. Both cases related back to the moment of surprise around the very wet storyline being more problematic than the wet storyline. In order to make new information / knowledge available and the mainstreaming thereof into day-to-day decision-making, the respondents indicated that communication and expert, as well as stakeholder, engagement would be crucial. Furthermore, a continual update on the latest research findings and other outcomes by appropriate write-ups and presentation was suggested, as well as maps to visualize impacts in detail and to demonstrate clear cause and effect linkages. Another advice was to use the terms risk, vulnerability and resilience in communication with decision-makers and politicians.

7.6 Discussions and Conclusion

In all workshops the participants were aware that the water resources in their respective catchment areas were already under threat because of challenges relating to unsustainable development pathways (settlements and agriculture), fragmented and un-

coordinated water resource management systems and the failure to enforce existing legislations. However, the true extent of current risks and threats, especially under conditions of projected climate change, was not known to any of the participants, which was alarming as this lack of knowledge inhibits the identification of priority areas and the proper allocation of resources in future planning. The participants found it challenging to make the climate change projections more relevant to their respective spheres of decision-making. All activities demonstrated that most South African catchments were unique in their biophysical and social characteristics and that interventions, whether from government or the private sector, could not be of a generic nature, but should rather address the characteristics of the specific catchment, i.e. climate change information needs to be contextualised and localised. Nevertheless, all workshops identified ecological infrastructure as a first step for adaptation, as well as strengthening the institutional format and governance arrangements. Furthermore, the need was identified for continual communication platforms at catchment scale, complemented by a statutory body as an implementing authority for the designed management interventions.

A review of the adaptation actions proposed in all workshops reveals that a number of themes emerged, these being:

(a) Governance issues,
(b) Mainstreaming of climate change into water management (e.g. regulation, design criteria),
(c) Infrastructure and technology developments,
(d) The need for planning,
(e) The need for education / awareness, and
(f) Implementation of early warning systems.

Additionally, numerous ‘moments of surprise’ were observed in all workshops held:

(a) Stakeholders identified re-occurring champion workshops as an opportunity for policy implementation.
(b) Moments of surprise in the Mgeni were the identification of the headwaters as being crucial in all three scenarios, *viz.* the dry, wet and very wet storyline. Furthermore, the wet storyline was – in certain aspects – more problematic than the very wet storyline. Building resilience via natural capital (the ecological infrastructure approach) was identified as a key activity.
(c) Moments of surprise in the Berg were that strong social networks of decision-makers and stakeholders exist, but overall responsibilities identified pointed

mostly to higher levels of governmental actors. Furthermore, the need for better law enforcement and monitoring were identified a key activities.

(d) The Mgeni technical workshop also revealed unexpected outcomes, such as the identification of positive impacts of climate change. Similar to the Mgeni champion workshop, the participants recognised that although the very wet storyline (with less certain changes) had the positive impact of delaying the need for developing new water resources infrastructure, it was still deemed to be an expensive storyline since the need to review existing infrastructure and technology and to perform necessary upgrades (for safety and stability) would be costly.

The moments of surprise clearly indicate the danger, especially for experts and water managers, of making assumptions based only on what they know, and point to the need to 'dig deeper' and reflect on issues in a participatory way and in a social learning environment in order to enable more informed decision-making in an optimal manner.

It needs to be noted here that a number of actions proposed involved improving current water management, e.g. clearing of drains, better law enforcement and infrastructure maintenance. This underlines the well-known benefits that can already be derived by simply managing current systems in an optimal manner.

In general, the design of adaptation options was mainly based on the champions' and participants' very personal knowledge and experience within the catchments and that of their working environment, *viz.* their organisation. Many of the proposed activities were focused on currently existing stressors as well as current initiatives and projects. In all cases it became clear that the design of adaptation activities would need considerable time and interaction.

In regard to governance and mainstreaming climate change into water management the participants stressed that the transition towards a sustainable and adaptive water resources management system (on national and catchment levels) would also need to be seen as a decision-making and leadership challenge partially perceived to being a function of higher governmental levels, *viz.* DWA, DEA and municipalities. For informed decision-making the need for an integrated communication strategy was emphasised, where this also provides for successful vertical as well as horizontal integration. Another key discussion point was monitoring systems being the backbone of sustainable water resource management. These need to provide accurate information

on the catchment and changes therein (e.g. water quality or water quantity) on a regular basis.

Overall, water managers already dealing with multiple stresses in the catchment, cannot easily use much of the existing climate change information in its current form in day-to-day decision-making. This points to the great need to bridge this gap between knowledge produced by science and knowledge relevant for decision-making. Neither the scientists nor the decision-makers felt that they were currently in a position to take on such a role. However, for knowledge creation and communication the science-society as well as the science-decision-maker interface was highlighted. Often this may require reframing the climate change and other findings which would need to be supported by identifying relational practices that would allow the translation of scientific information to a societal and then decision-making context (e.g. participatory scenario development, group model building).

Generally, the five workshops were successful in regard to moving towards a common understanding of the respective catchments, learning collectively about existing vulnerabilities and so-called hotspots, as well as gaining a better understanding of the projected impacts of climate change on the catchment areas. More long-term engagement is required when it comes to identifying coordinated catchment and decision-maker specific adaptation options. Long-term engagement and future learning opportunities are also required for improving engagement and collaboration of the various organisations involved in water resources management. Therefore, it seems crucial that the participants be provided with the time and support (including financial) from their respective organisations to participate in such workshops (i.e. capacity and training initiatives that cross organisational boundaries need to be encouraged more). Participants valued especially the networking opportunities among each other and the information sharing with regard to existing initiatives.

In conclusion, adaptation design calls for an enabling environment that gives space for knowledge exchange and learning conversations. That caters for the interplay of systemic, organisational and individual needs of stakeholders. Such conversations cannot be undertaken without participation by a mix of decision-makers and stakeholders because of the uncertainties of development trajectories, as well as limited data and knowledge of the impacts and their interlinkages. It needs to be further highlighted that adaptation design and implementation needs to be combined with the necessary budgets and that they require substantial and recurring time commitments.

7.7 Acknowledgements

This research has been made possible through funding from the Water Research Commission of South Africa (WRC Project K5/1843). The authors' sincerer thanks also go to all those stakeholders and champions who made available some significant time within their busy daily schedules to explore the opportunities envisaged by the workshops.

7.8 References

DEAT (2006). *South Africa Environment Outlook. AReport on the State of the Environment*. Pretoria, South Africa.

De la Harpe, J., Ferriera, J. A. & Potteral, A. (undated). *Water Management Institutions Overview*. Department of Water Affairs and Forestry. Pretoria, South Africa.

Dent, M. (2012). Catchment management agencies as crucibles in which to develop responsible leaders in South Africa. *Water SA*, 38(2), 1-13.

Folke, C., Hahn, T., Olsson, P. & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environmental Resources*, 30, 441-473.

Hjerpe, M. & Glaas, E. (2012). Evolving local climate adaptation strategies: incorporating influences of socio–economic stress. *Mitigation and Adaptation Strategies for Global Change*, 17(5), 471-486.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, 4, 390-405.

Huntjens, P., Lebel, L., Pahl-Wostl, C., Camkin, J., Schulze, R. & Kranz, N. (2012). Institutional design propositions for governance of adaption to climate change in the water sector. *Global Environmental Change*, 22, 67-81.

IPCC (2014). *Climate Change 2014. Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral* Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, USA.

Inderberg, T. H. & Eikeland, P. O. (2009). Limits to adaptation: analysing institutional constraints. In: Adger, W. N., Lorenzoni, I., O'Brien, K. L. (Eds) *Adaptation to Climate Change: Thresholds, Values, Governance*. Cambridge University Press, Cambridge, UK. Ch. 27, 433-447.

Isendahl, N., Dewulf, A., Brugnach, M., François, G., Möllenkamp, S., & Pahl-Wostl, C. (2009). Assessing framing of uncertainties in water management practices. *Water Resources Management*, 23(15), 3191-3205.

Ison, R., Collins, K., Colvin, J., Jiggins, J., Roggero, PP., Seddaiu, G., Steyaert, P., Toderi, M. & Zanolla, C. (2011). Sustainable catchment managing in a climate changing world: New integrative modalities for connecting policy makers, scientists and other stakeholders. *Water Resources Management*, 25, 3977-3992.

Jones, J. A. (2011). Hydrological responses to climate change: considering geographic context and alternative hypotheses. *Hydrological Processes*, 25(12), 1996-2000.

Kotter, J. & Rathgeber, H. (2005). *Our Iceberg is Melting. Changing and Succeeding Under Any Conditions*. St. Martin's Press, New York, USA.

Loorbach, D. A. (2007). *Transition Management. New mode of governance for sustainable development.* Unpublished PhD Thesis, Erasmus University of Rotterdam, Rotterdam, The Netherlands.

Loorbach, D. (2010). Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance: An International Journal of Policy, Administration, and Institutions*, 23(1), 161-183.

MacKay, H. M., Rogers, K. H. & Roux, D. J. (2003). Implementing the South African water policy: Holding the vision while exploring an uncharted mountain. *Water SA*, 29(4), 353-358.

Mostert, E., Pahl-Wostl, C., Rees, Y., Searle, B., Tàbara, D. & Tippett, J. (2007). Social learning in European river-basin management: barriers and fostering mechanisms from 10 river basins. *Ecology and Society*, 12(1), 19.

National Planning Commission of South Africa (NPC) (undated). Diagnostic Overview. [Internet]. Pretoria, South Africa. Available from: http://www.npconline.co.za/MediaLib/Downloads/Home/Tabs/Diagnostic/Diagnostic%20Overview.pdf [Accessed 9 August 2013]

Ngcobo, S., Jewitt, G. P. W., Stuart-Hill, S. & Warburton, M. (2013). Impacts of global change on Southern African water resources systems. *Current Opinion in Environmental Sustainability*, 5(6), 655-666.

Pahl-Wostl, C. (2007). Transitions towards adaptive management of water facing climate and global change. *Water Resource Management*, 21, 49-62.

Pahl-Wostl, C., Jeffrey, P., Isendahl, N. & Brugnach, M. (2011). Maturing the new water management paradigm: Progressing from aspiration to practice. *Water Resources Management*, 25, 837–856.

Pahl-Wostl, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D. & Taillieu, T. (2007). Social learning and water resources management. *Ecology and Society*, 12(2), 5.

Pahl-Wostl, C. & Rettig, C. (2010). Personal communication. Osnabrück, Germany.

Republic of South Africa (1997). *National Water Services Act.* No. 108 of 1997. Government Printer, Pretoria, South Africa.

Republic of South Africa (1998). *National Water Act. Act.* No. 36 of 1998. Government Printer, Pretoria, South Africa.

Roux, D. J., Rogers, K. H., Biggs, H. C., Ashton, P. J. & Sergeant, A. (2006). Bridging the science-management divide: moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecology and Society*, 11(1), 4.

Sherwill, E., Arendse, L., Rogers, K., Sihlophe, N., van Wilgen, B., van Wyk, E. & Zeka, S. (2007). Stakeholder connectedness and participatory water resource management in South Africa. *Water SA*, 33(4), 505-512.

Schulze, R. E. (2008). Integrated water resources management as a medium for adapting to climate change: Conceptual, scaling, impacts modelling and adaptation issues within a southern African context. Petermann T., (ed.): Towards Climate Change Adaptation – Building Adaptive Capacity in Managing African Transboundary River Basins, InWent, Zschortau, Germany, 41-74.

Schulze, R. E. (ed) (2012). *A 2011 Perspective on Climate Change and the South African Water Sector*. WRC Report TT 518/12. Water Research Commission, Pretoria, South Africa.

Someshwar, S. (2008). Adaptation as 'climate-smart' development. *Development*, 51, 366-374.

Stuart-Hill, S. I. & Pahl-Wostl, C. (in preparation). Mainstreaming adaptation to climate change: taking organisational issues into consideration for successful management interventions. *Ecology and Society*, Special Feature "The Governance of Adaptation".

Stuart-Hill, S. I. & Schulze, R. E. (in preparation). A snapshot of South Africa's water resource management status. What does this indicate for overall water governance? *Journal of Environmental Management*.

Stuart-Hill, S. I. & Schulze, R. E. (2010). Does South Africa's water law and policy allow for climate change adaptation? *Climate and Development*, 2, 128-144.

Stuart-Hill, S.I., Herrfahrdt-Pähle, E. & Pahl-Wostl, C. (in preparation). Mainstreaming adaptation: Preparing decision-making in the water sector. *Environmental Science and Policy.*

Taylor, A., Cocklin, C. Brown, R. & Wilson-Evered, E. (2011). An investigation of champion-driven leadership processes. *The Leadership Quarterly*, 22, 412-433.

Taylor, A. C. (2010). Building leadership capacity to drive sustainable water management: the evaluation of a customised program. *Water Science & Technolog*, 61.11, 2797-2807.

Termeer, C. J. A. M. (2009). Water professionals and public leadership. *Irrigation and Drainage*, 58, S212-S216.

Technical Committee (TEC) GWP (2004). *Catalysing Change: A Handbook for Developing Integrated Water Resources Management (IWRM) and Water Efficiency Strategies*. Stockholm, Sweden.

Vennix, J. A. M. (1996). *Group Model Building. Facilitating Team Learning Using System Dynamics*. John Wiley & Sons. Chichester, UK.

Vennix, J. A. M. (1999). Group model-building: Tackling messy problems. *System Dynamics Review*, 15, 379-401.

Vogel, C., Moser, S. C., Kaspersonc, R. E. & Dabelko, G. D. (2007). Linking vulnerability, adaptation, and resilience science to practice: Pathways, players, and partnerships. *Global Environmental Change*, 17, 349-364.

Warburton, M. L. & Schulze, R. E. (2010). Water resources management in South Africa: Should the focus be on land use change, climate change or both? *Geophysical Research Abstracts*, 12, EGU2010-7717.

Woddhill, J. (2010). Capacities for institutional innovation: A complexity perspective. *IDS Bulletin*, 41(3), 47-59.

7.9 Annexure 1: Evaluation of Group Model Building Workshops

Dear workshop participants,
As we intend to use the approach of Group Model Building and scenario development again in future situations, we would like to learn from your feedback and experiences from today's workshop. Therefore we would like to ask you to answer the questions below. It will only take a few minutes. Your answers will be analyzed anonymously. Thanks a lot for your cooperation!
Roland Schulze (UKZN), Sabine Stuart-Hill (UKZN), Nadine Methner (UCT)

Please fill in and give to facilitators or observers, or email to Stuart-Hills@ukzn.ac.za or fax to 033 260 5818.

Objectives of the workshop:

- *Create a joint understanding of the catchment and its hydrological as well as biophysical and socio-economic processes/interactions through the group model building.*
- *Create a better understanding of climate change triggered vulnerabilities specific to the Mgeni catchment through the introduction of the latest scientific findings on climate change and its impacts on the catchment.*
- *Based on these joint findings and experiences, explore strategies for adapting to climate change in the catchment.*

1. On a scale from 1 (not useful at all) to 10 (very useful), how would you rate the usefulness of Group Model Building for achieving the objectives of the workshop?

2. How could the Group Model Building applied today be valuable or useful for your day-to-day work and decision-making?

3. Based on your experience today, how would you describe the benefits of Group Model Building for water resource management in the catchment?

4. From your engagement with the process what are the drawbacks of Group Model Building?

5. Has using this method helped you to gain new knowledge and insights? If so, how would you describe these?

6. Which part of the modelling process has benefited you the most: creating a joint understanding by building a model, the provision of scientific information by the facilitators or the joint mapping of water sensitive and dependent activities?

7. Thinking back about the day, to what extent do you agree or disagree with the following statements?

		Strongly disagree	Dis-agree	Agree	Strongly agree	Don't know
a	Participants presented a balanced and comprehensive mix of interests. Comment:	☐	☐	☐	☐	☐
b	The location was inconvenient for me. Comment:	☐	☐	☐	☐	☐
c	The workshop was well moderated. Comment:	☐	☐	☐	☐	☐
d	The activities and exercises were easy to follow. Comment:	☐	☐	☐	☐	☐
e	The workshop involved too much work. Comment:	☐	☐	☐	☐	☐
g	I felt comfortable to share my views and opinions. Comment:	☐	☐	☐	☐	☐
h	The other participants were willing to listen to my contributions. Comment:	☐	☐	☐	☐	☐
i	The workshop helped me to get to know the other participants better. Comment:	☐	☐	☐	☐	☐
j	The workshop helped me to learn about the views and opinions of the other participants. Comment:	☐	☐	☐	☐	☐
k	The workshop helped me to structure my own thoughts on the topic of climate change. Comment:	☐	☐	☐	☐	☐

Thank you very much for filling out this evaluation questionnaire.

7.10 Annexure 2: Exemplary Other Evaluation Questionnaires

These questions were handed out on the day of the workshop; evaluation by champions took place either on the day or a few days later.

1. Have you gained sufficient knowledge through the workshop for informed decision-making on climate change in the Mgeni catchment? If possible, please list main points of knowledge you gained as well as gaps you identified.
   Knowledge:
   Gaps:

2. A) On a scale from 1 (low level) to 10 (high level) how would you rate your level of awareness of climate change impacts and vulnerabilities you have gained through this workshop?
   B) Would you like to have further exchange on the topic of climate change, its impacts, and vulnerabilities?

3. Would you need more or other knowledge in order to make well-informed / qualified decisions? Please give ideas and examples.

4. What kinds of questions are currently being discussed in terms of water management in your department / organization that should have a climate change dimension?

5. Other issues you would like to raise …

These questions were emailed to all participants of the workshop after 4 to 5 months.

1. Have any of your decisions lately been influenced by the experiences gained during the workshop from 23rd January 2013? Please explain why.

2. Would you need more or other knowledge in order to make well-informed / qualified decisions? Please give ideas and examples.

3. Have any decisions on non-water topics been influenced by the knowledge you have gained at the workshops?

4. Have your perceptions changed based on your knowledge and experiences from the workshop when performing your daily work and especially when you are taking decisions? Please explain why/how.

5. How could new information on climate change and water (impacts & vulnerabilities) be best …
   a. presented to maximize your benefit there of?
   b. mainstreamed into your work?

7.11 Annexures 3 to 6

Annexure 3: Report of first Mgeni workshop

The Mgeni river catchment workshop: 16th of February 2011

Funded by the Water Research Commission and National Research Foundation of South Africa

Organizers and their contact details:
Nadine Methner (UCT), nmethner@csag.uct.ac.za, 073 035 1915
Sabine Stuart-Hill (UKZN), Stuart-Hills@ukzn.ac.za, 033 260 5460

I. BACKGROUND

This workshop was targeted at catchment champions[1] who work in various institutions involved in the management of the Mgeni river catchment. In the workshop a group modelling exercise[2] was used with the aim to create a common ground of understanding and to gain knowledge on sensitivities of the catchment. The exercise was also intended to enquire about current understandings of the champions with regard to the hydrological characteristics and specific functioning of the Mgeni river system as well as to test existing understanding and awareness of potential climate change impacts in the catchment. Another important component of the workshop was that the champions, together with the researchers, explored how to better mainstream climate change information into their decision making and to find avenues for improving existing management practices in the catchment.

Specific workshop objective of the workshop:

(a) Create a joint understanding of the catchment and its hydrological as well as biophysical and socio-economic processes/interactions through the group model building.
(b) Create a better understanding of climate change triggered vulnerabilities specific to the Mgeni catchment through the introduction of the latest scientific findings on climate change and its impacts on the catchment.
(c) Based on these joint findings and experiences, explore strategies for adapting to climate change in the catchment, including options for improving decision making and strengthening water management institutions and their collaboration with regard to water resources management.

[1] The participants in the catchment were chosen so that a fair representation of major organizations involved in the management of the specific catchment areas was ensured. Furthermore the participants had been previously identified as 'champions'. That is they are leaders and experts in their respective spheres of influence, they have a good understanding of the catchment area and possessed the required institutional memory to provide valuable inputs to the discussions.

[2] See Appendix 1 for an introduction to the concept (omitted here owing to length)

The Mgeni catchment workshop participants:

Name	Organization	Function	Contact details
Manisha Maharaj	Department of Water Affairs	Water Quality Management	thakurdinm@dwa.gov.za 031 336 2750, 082 808 1191
Douglas Chapman	KZN DAEA & RD	Agricultural Risk and Disaster Management	DouglasChapman@kzndae.gov.za 033 343 8142
Bart Fokkens	DUCT	Implementation Manager	bart@duct.org.za 082 455 7934
Bryan Ashe	Geasphere KZN / Mvula Trust	Coordinator and Trainer	earthbryan@gmail.com 082 652 1533
Mark Graham	GroundTruth	Aquatic Ecologist	mark@groundtruth.co.za 033 342 6399
Lyn archer	Umgeni Water	Environmental Scientist	Lyn.archer@umgeni.co.za 083 274 1330
Chris Fennemore	EWS eThekwini Municipality	Manager - Pollution & Environment Branch	christfe@dmws.durban.gov.za 082 804 6386
Vanashrie Govender	eThekwini Municipality	Coastal, Stormwater and Catchment Management	GovenderVanashrie@durban.gov.za 031 311 7217
Ian Felton	KZN DAEA & RD	Environmental Planning	Ian.felton@kzndae.gov.za 033 347 1820

II. WORKSHOP FORMAT

Overview of the workshop format:

Sessions	Content	Outcomes
Session 1: Creation of a joint catchment model	Major factors that impact water availability in the catchment area and important feedback loops	Understanding the functioning of the catchment area
Session 2: Mapping of sensitive areas and water dependent activities	Topographic mapping of sensitive areas (upper to lower catchment)	Identification of areas of concern and their causes
Session 3: Overview of the latest scientific findings of potential CC impacts in the catchment areas	Projections for the Mgeni: • Higher risks of floods • Increase in run-off because of more rain events • Higher evaporation rates	Climate change beyond the 'black box'
Session 4: Reassessment of catchment model through a climate change lens	• Potential impacts • Needs	Future threats and existing obstacles

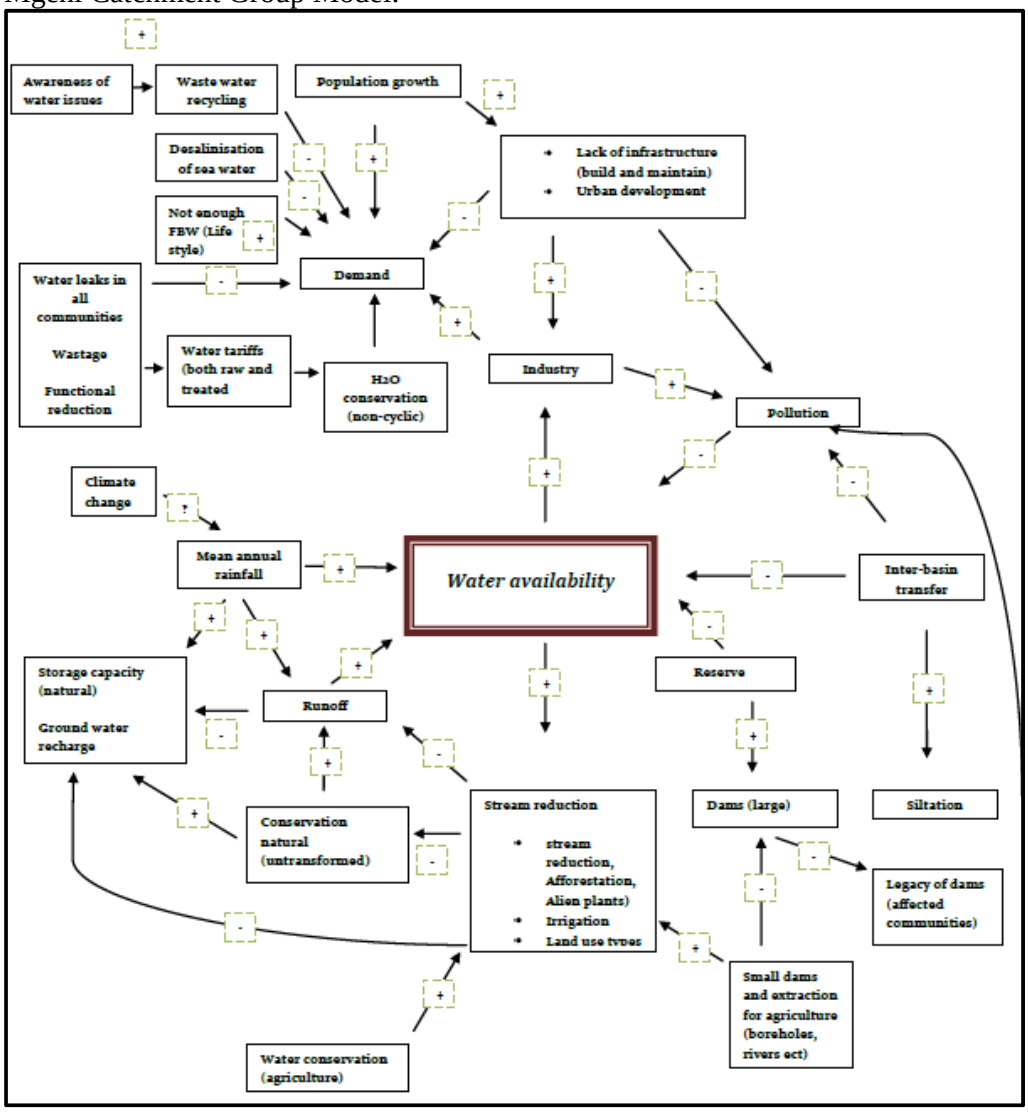
Session 5:Exploring adaptation options	Adaptation strategies	Identification of priorities, and potential obstacles

III. SUMMARY OF WORKSHOP SESSIONS

Session 1: The Mgeni Catchment Group Model: "What Influences Water Availability In The Catchment?"

The Group Model below shows two key aspects identified by the group that influence water availability in the catchment. These are "Demand" and "Pollution" and they are strongly influenced by other issues, i.e. many interlinkages and connections pointing towards these cards/issues. Furthermore, "stream flow reduction activities" and "dams" (big and small) have been placed amongst the natural hydrological variables on the lower part of the model / paper.

Mgeni Catchment Group Model:



It became quite clear that besides climatic factors such as rainfall, land use practices, urbanization pressures, alien vegetation, the state and operation of existing infrastructures (e.g. waste water treatment plants) and resultant pollution influence strongly the water availability in the catchment. Major emphasis in the discussion was put on the poor state of existing infrastructure, the impact of stream flow reducing activities and the current wastage and pollution of existing water resources. It was pointed out that the ecological reserve determination has not been finalized yet for the catchment and that this is expected to further impact negatively on the water availability for ecological systems in the Mgeni catchment.

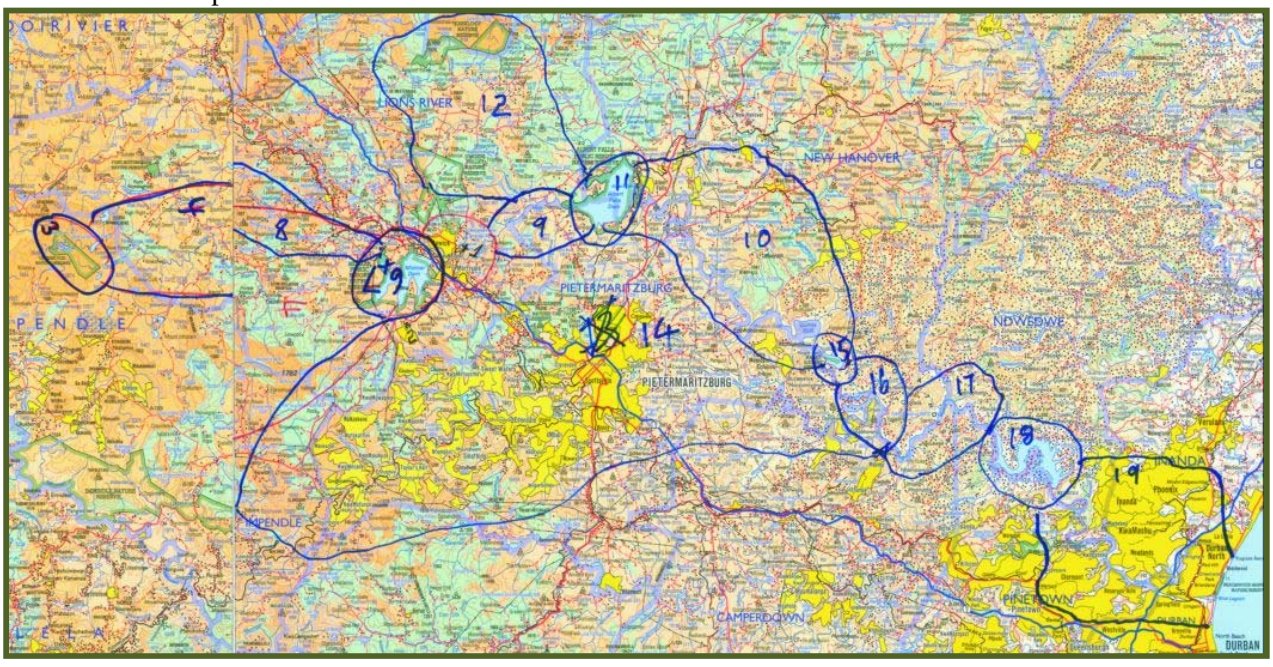
Current urbanization trends and population growth are also drivers that will impact water availability in the Mgeni. For example the water demand is increasing faster than population growth due to increased expectations and lifestyles.

The modelling exercise helped the participants to understand the non-linear feedback loops between the different factors and also provided some common understanding in preparations for Prof. Schulze's presentation on climatic and hydrological trends under climate change in South Africa and more specifically in the Mgeni catchment.

Session 2: Mapping of Sensitive Areas

This exercise was of great value for everyone (participants and scientists) as it really allowed to locate important vulnerability hotspots in the catchment and associated causes. A list of all identified sensitive areas in the Mgeni catchment is shown below.

Catchment map with identified sensitive areas:



Description of identified sensitive areas:

1. Howick Wastewater Works and associated infrastructure, the urban/ industrial area – pollution caused by urbanization and industry
2. Howick Township
3. Umgeni Vlei – Source is in good condition but threatened by development/drainage
4. Dargle to Midmar - intensive agricultural activities (chicken, piggeries, dairy)
5. Timber/ Plantation area
6. Midmar Dam - its importance for recreational activities, hence, the importance of water quality
7. Midmar Dam - water supply: to Howick, Pietermaritzburg and Richmond
8. Lions river - flooding of wetlands (inter-basin transfer)
9. Howick to Albert Falls Dam - natural purification because of intact habitats (Mgeni Nature Reserve)
10. Albert Falls Dam - increase in pollution, housing developments
11. Albert Falls to Nagle Dam - erosion, intensive agriculture, alien vegetation (wattle, lantana)
12. Karkloof - expansion of natural forest rehabilitation hence, clean water source
13. Alien vegetation: more problematic in lower catchment areas is not such a big issue in the upper catchment area, but important for “muti” and as firewood
14. Mzunduze - significant pollution problems (e.g. Edendale, etc- lack of sewage; lack of stormwater drainage), excessive aliens; Pietermaritzburg City: inappropriate development in riparian areas and floodplains
15. Nagle Dam - important for recreational activities and water supply
16. Nagle to Duzi confluence - no environmental flow release
17. Confluence to inflow into Inanda Dam - lots of pressures from peri-urban areas and industry, sand mining, failing WWT plant
18. Inanada Dam - water supply, legacy of displaced communities, eutrophication, aquatic aliens
19. Inanda to Blue Lagoon - sewage pollution from 5 pump stations, storm water infiltration, impact of sand mining, impacts of informal settlements
20. Inter-basin transfer

Session 3: Overview of the Latest Scientific Findings of Potential Climate Change Impacts in the Catchment Areas

Please note, that this appendix has been omitted owing to its size.

Session 4: Reassessment of the Mgeni Catchment Model Through a Climate Change Lens: Impacts, Needs and Adaptation Options

IMPACTS

- Movement of people leading to diseases/food security
- Greater storm water infiltration
- Hydraulic overload of sewer infrastructure
- Blocking of infrastructure
- Less water availability
- Increase in population and decrease in dilution leading to increase eutrophicates
- Alien plants – aquatics and terrestrial
- More rain-but again there is greater evaporation
- Upper catchment are important to manage (water quality, sediments-less transformation in these upper catchments)
- Increase in flooding impacts on infrastructure (roads, bridges, sewage etc.)
- Storm water management and planning needs to account for floods
- Hydrologic overload of sewer infrastructure

NEEDS

- Higher resolution of climate change impacts (information and vulnerabilities)
- Translates between science and policy
- Translates of information/ policies from national to regional and local
- Awareness on climate change is needed, policies and laws are in place
- Criteria and indicators limited to laws in order to create obligations/implication and law enforcement
- Integration across departments and sectors
- Institutionalise policies on climate change
- Education and awareness on climate change (to change people's attitudes)
- Relook at 1:50 and 1:100 flood lines

ADAPTATION OPTIONS / STRATEGIES

- Sustaining upper catchment area
  (preserve or conserve upper catchment in its pristine stage)
- Establish coastal line to deal with sea level rise
- Relook at flood line specifically 1/100 years
- Redesign infrastructure
- Review water quality discharge standards
- Reserve determination
- Assess solid waste management
- Review overall storm water management
- Incorporate climate change into land use planning, specifically at local level
- Incorporate climate change into policy and ensure implementation
- Identify priorities ... (buffer, sinks)-precautionary principle, mitigation)
- Capacitating NGOs and other groups to inform the poor and the vulnerable
  - Explore for example water services for risk awareness
- Explore rain water harvesting for all types of houses/settlements (there is a huge problem with this adaptation because people don't trust the source and that an investment in gutters is high
- Revisit all by-laws (review water quality standards and reserve determination)
- Sea water desalinisation (bear in mind the costs associated)

Based on Professor Schulze's presentation the participants came to the conclusion that if existing institutional and infrastructure challenges are not adequately addressed, climate change will amplify existing threats. This is particularly true when it comes to pollution of the water resources and disaster risk management as current projections seem to indicate an increase in local and regional floods in the Mgeni catchment due to increased rainfall. See below for more details.

IV. MAJOR POINTS RAISED BY THE PARTICIPANTS IN THE WORKSHOP DISCUSSIONS

The participants stressed that the transition towards a sustainable and adaptive water resource management system (national and catchment level) must be seen as a higher decision making problem. In particular existing policies need to be revisited and obstacles for a flexible yet sustainable management approach need to be removed. Central government must for example ensure that new mandates relegated to local government (i.e. municipalities and WUAs) must also be combined with the necessary budgets to implement these mandates. Furthermore it was stressed that for the practical implementation of climate change adaptation strategies local decision makers require guidance through appropriate by-laws.

In the workshop the need of an **integrated communication strategy** was accentuated. This communication strategy must link all organizations that are involved in the management of the catchment and must provide for successful vertical as well as horizontal integration. Currently many organizations continue to work in silos with little knowledge of the activities of other organizations. This fragmented approach is one of the greatest obstacles to realize systematic monitoring of current trends and effective implementation of initiatives.

Monitoring systems that provide accurate data about trends and changes in the catchment (e.g. water quality or water quantity) on a regular basis are the backbone of sustainable water resource management. The majority of champions emphasized that without such systems in place they will not be able to make informed decisions on current and future changes in the catchment. Such monitoring systems do not only need to capture water quality, water consumption and land use changes but must also account for new challenges such as new types of pollutants (e.g. growth hormones and pharmaceuticals.) This in turn requires sufficient funding for the creation and maintenance of adequate monitoring systems as well as close coordination between different organizations involved in the monitoring activities, including a productive science – decision maker interface. The link between scientists and water resource managers is not only crucial for ensuring that all relevant factors are considered in the monitoring process but also that the translation of data into information speaks to the needs of the water managers.

Another factor that was stressed in the workshop is the **science society interface and the role of knowledge creation and communication**. Although the scientific findings presented by Prof. Schulze and Sabine Stuart Hill were highly valued by the participants, they also were concerned how this scientific information could become

more relevant for their daily work. There is a general acknowledgement that increasingly better information (e.g. fine scale information) is required at local decision making level in order to be able to deal with the complexity and uncertainty in the South African water sector. Yet a lot of the existing information, in its current form, cannot be easily used in the day to day decision making. This points to the great need to bridge the gap between scientific information and decision making relevant knowledge. Neither the scientists nor the decision makers felt that they are currently in a position to take on such a role.

The discussions on climate change impacts demonstrated that many use the term climate change but at the same time there is limited understanding about its causes and projected impacts and how these impacts relate to water availability and water management in South Africa. This shows that decision makers at all level need to be more sensitized.

V. REFLECTION AND DISCUSSION ON THE VALUE AND OUTCOMES OF THE WORKSHOP:

The workshop can be seen as a starting point in moving towards a common understanding of the respective catchment, learning collectively about existing vulnerabilities and so called hotspots as well as gaining a better understanding on the projected impacts of climate change in the catchment. More long term engagement is required when it comes to identifying coordinated catchment and decision maker specific adaptation options. Long term engagement and future learning opportunities are also required for improving engagement and collaboration of the various organizations involved in the water resources management.

The participants were aware that the water resources in their catchment are already under significant stress because of challenges relating to unsustainable development pathways (housing and agriculture), fragmented and uncoordinated water resource management practices and the failure of enforcing existing legislations. However, the true extent of current risks and threats is not known to any of the participants, which is alarming as this lack of knowledge inhibits the identification of priority areas and the proper allocation of resources. With regard to climate change and its impacts on the Mgeni, the participants are alerted that future climate change projections will most likely affect water availability (relating to quantity and quality) negatively. Yet, participants found it challenging to make these projections more relevant to their respective spheres of decision-making.

Participants valued especially the networking opportunities amongst each other and the information sharing with regard to existing initiatives. However, the three core activities (creating a joint understanding by building a model, the provision of scientific information on climate change impacts in the Mgeni catchment, joint mapping of water sensitive and dependent activities) were each rated most beneficial by two participants each, while one champion rated them all three as equally beneficial.

The usefulness of the Group Model Building in regards to achieving the workshops objectives was rated as useful, with even two ratings of 9 and 10 out of 10. Nevertheless, three of the eight participants rated the work as not useful for their day to day work interestingly 2 of those were from local government. The 5 other participants rated the work as very useful specifically for strategic planning, decision making as well as identifying linkages and relationships between sectors. However, most of the participants pointed out that the Group Model Building needs more time but that it did provide valuable insight and a broader picture.

Overall, the champions were positive about the activities of the workshop and its outcomes, but the evaluations as well as other assessments have shown that there is room for improvement and optimization. Consequently, further activities will be envisaged including the actions under section VI.

VI. THE WAY FORWARD AND NEXT STEPS

The atlas on climate change impacts in South Africa being currently finalized by Prof. Schulze will be made available to the champions. A variety of follow-up and evaluating activities, taking into consideration the time constraints of everyone involved, will be conducted by Sabine Stuart-Hill in the weeks following the sent out of this document.

In a few months a follow-up workshop is planned in order to explore further activities aiming at deepening the understanding of decision making and mainstreaming in the Mgeni catchment. An update on the latest scientific findings will be given and as far as possible the workshop will build on the Group Model Building and mapping exercise undertaken in the first workshop.

Annexure 4: Report of first Berg workshop

The Berg River catchment workshop: 18th of February 2011

Funded by the Water Research Commission, the National Research Foundation of South Africa and the Department of Water Affairs

Organizers and their contact details:
Nadine Methner (UCT), nmethner@csag.uct.ac.za, 073 035 1915
Sabine Stuart-Hill (UKZN), Stuart-Hills@ukzn.ac.za, 033 260 5460

I. BACKGROUND

This workshop was targeted at catchment champions[3] that work in various institutions involved in the management of the Berg River catchment. In the workshop a group modelling exercise[4] was used with the aim to create a common ground of understanding and to gain knowledge on sensitivities of the catchment. The exercise was also intended to enquire about current understandings of the champions with regard to the hydrological characteristics/functioning of river systems as well as to test existing understanding and awareness of potential climate change impacts in the catchment. Another important component of the workshop was that the champions, together with the researchers, explored how to better mainstream climate change information into their decision making and to find avenues for improving existing management practices in the catchment.

Specific workshop objective of the workshop:

(a) Create a joint understanding of the catchment and its hydrological as well as biophysical and socio-economic processes/interactions through the group model building.
(b) Create a better understanding of climate change triggered vulnerabilities specific to the Berg catchment through the introduction of the latest scientific findings on climate change and its impacts on the catchment.
(c) Based on these joint findings and experiences, explore strategies for adapting to climate change in the catchment, including options for improving decision making and strengthening water management institutions and their collaboration with regard to water resources management.

[3] The participants in the catchment were chosen so that a fair representation of major organizations involved in the management of the specific catchment areas was ensured. Furthermore the participants had been previously identified as 'champions'. That is they are leaders and experts in their respective spheres of influence, they have a good understanding of the catchment area and possessed the required institutional memory to provide valuable inputs to the discussions.

[4] See Appendix 1 for an introduction to the concept (omitted here owing to size)

The Berg catchment workshop participants:

Name	Organization	Function	Contact details
Derril Daniels	Department of Water Affairs	Berg catchment manager	DanielsD@dwa.gov.za 021 950 7267, 082 908 3236
Leon Davids	Department of Water Affairs	Hydrology	davidsl@dwa.gov.za 021 950 7197
Melissa Pieterse	Working for Water	Acting catchment manager	Pietersem@dwa.gov.za 0823209110
Wessel Wenzel	Working for Water	Implementation manager	Wessel@dwa.gov.za 0828887766
Catherine Bill	DEA&DP	Ass. Director: Pollution	cbill@pgwc.gov.za 021 483 2760
Elmo Maree	Provincial Department of Agriculture	Land care manager	ElmoM@elsenburg.com 021 8731135/6
Lizell Liesing	Office of the Premier Western Cape	Policy Advisor	Lliesing@pgwc.gov.za 0214836270
Martin Albertus	Cape Winelands District Municipality	Ass. Director Environmental Planning	malbertus@environment.gov.za 021 888 5121
Ronald Brown	Drakenstein Municipality	Directorate : Civil Engineering	Ronald.Brown@drakenstein.gov.za 021 807 4725
Jimmy Knaggs	Drakenstein Municipality	Environmental Management	jimmy@drakenstein.gov.za 021 807 4707
Jannie Kirsten	Berg Pollution Action Committee	Chairman	jannie@jdk.co.za 0823144620
Jeanne Gouws	Cape Nature	Aquatic Scientist	jgouws@capenature.co.za 021 866 8012
Johann Conradie	Benede Berg River IB	Chairman	jjc@conradieboerdery.co.za 082 944 8800
Willie Enright	Waterright Consulting	Expert: water management	enright@absamail.co.za 0828073535
Prof. Jo Barnes	University of Stellenbosch	Water quality & Health expert	jb4@sun.ac.za 021 938 9480
Brett Keyser	Stellenbosch Municipality	Manager: Water and Wastewater Treatment	brettk@stellenbosch.org 021 808 8250

III. WORKSHOP FORMAT

Overview of the workshop format:

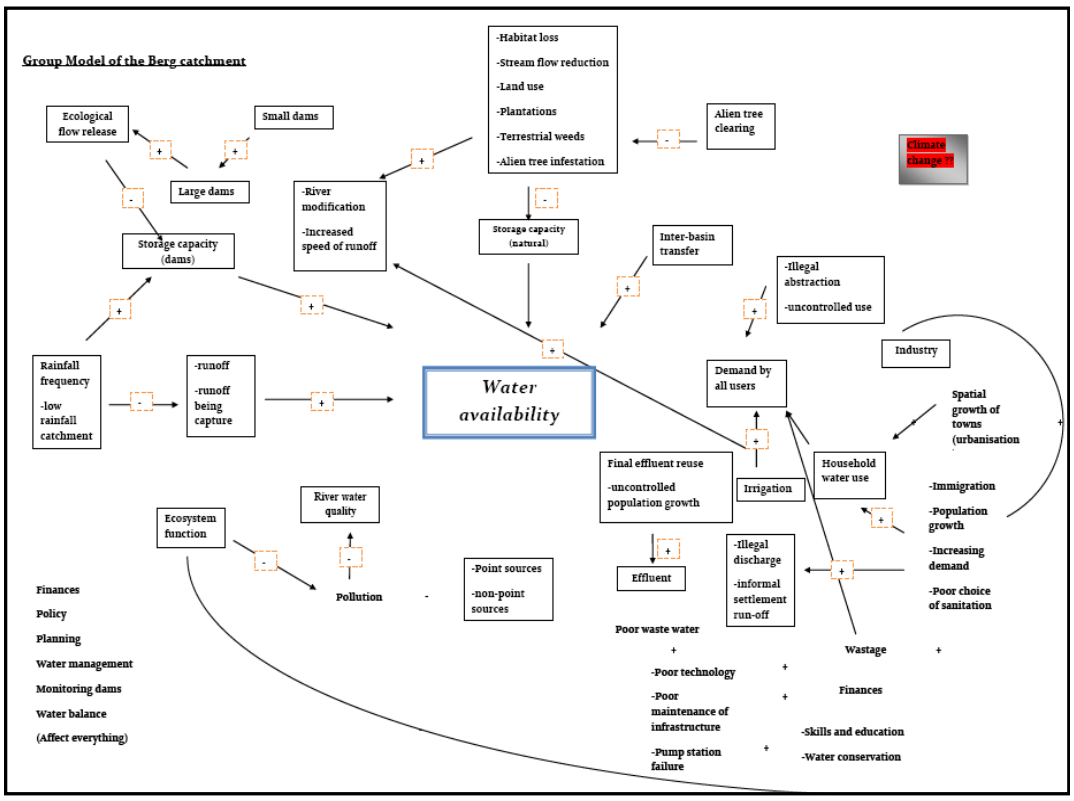
Sessions	Content	Outcomes
Session 1: Creation of a joint catchment model	Major factors that impact water availability in the catchment area and important feedback loops	Understanding the functioning of the catchment area
Session 2: Mapping of sensitive areas and water dependent activities	Topographic mapping of sensitive areas (upper to lower catchment)	Identification of areas of concern and their causes
Session 3: Overview of the latest scientific findings of potential CC impacts in the catchment areas	Projections for the Berg • Less rainfall during winter months • Drier and hotter • High evaporation rates	Climate change beyond the 'black box'
Session 4: Reassessment of catchment model through a climate change lens	• Potential impacts • Needs	Future threats and existing obstacles
Session 5:Exploring adaptation options	Adaptation strategies	Identification of priorities, and potential obstacles

IV. SUMMARY OF WORKSHOP SESSIONS

Session 1: The Berg Catchment Group Model: "What Influences Water Availability In The Catchment?"

It became quite clear that besides climatic factors such as rainfall, land use practices, urbanization pressures, alien vegetation, the state and operation of existing infrastructures (e.g. waste water treatment plants) and resultant pollution influence strongly the water availability in the catchment. Major emphasis in the discussion was put on the poor state of existing infrastructure, the impact of stream flow reducing activities and the current wastage and pollution of existing water resources. Several participants pointed out that water availability in the upper catchment is determined by different factors then in the lower catchment. This demonstrates how unique the catchment is in its biophysical and social characteristics and that interventions, whether from government or the private sector, cannot be generic but must speak to the characteristics of the specific sub catchments.

Berg catchment group model:



Given that issues of water quality are of great concern in the Berg catchment lots of emphasis was put on how pollution and alien invasive vegetation impact water availability and water balance in the Berg. The discussion further revealed that in-migration, in particular the steady and uncontrolled influx people from low-income brackets, places enormous stress on the water resources. However, this risk factor has been given little attention at higher decision-making levels.

Session 2: Mapping of Sensitive Areas

Most of the identified hotspots are linked to either pollution causes by the WWT plants and associated infrastructure, urban areas along the river where waste from formal and informal settlements is directed into storm water canals, or terrestrial and aquatic alien vegetation. Illegal activities in some sub catchment areas and non-sustainable agricultural land use practices also add to the problem of degrading water quality. Currently the exporting agricultural sector (e.g. viticulture, horticulture, deciduous fruits and field vegetables) is threatened the most from the degrading water quality. However, supporting economic activities are also at great risk. What seems to be alarming is that the true extent of pollution levels in the Berg cannot be really determined as current pollution hotspots have been identified based on historic data and sampling sites without taking into consideration all major pollutants. The lack of a systematic monitoring and communication system also contributes to the problem. Consequently a poor understanding of the real risks exists at all decision-making levels. Especially

current and future health risks have not been considered at the relevant decision making levels.

Catchment map with identified sensitive areas:

Description of identified sensitive areas:

1. Drakenstein municipality-Wetland mapping (4000), shape files are available
2. Fresh water ecosystem priority areas- have been identified and mapped by CSIR
3. WWT plants in the Upper Berg catchment area
4. Tullbach Valley- lots of illegal activities
5. Berg river dam- pristine water up to Wemmershoek dam (first 10km)
6. Exporting Farmers- all along the Berg river (from Wemmershoek dam to Boesemans River)
7. Degraded water quality a big threat
8. Stellenbosch and Drakenstein municipality-Land use mapping for irrigation
9. Aquatic weed
    a. Paarl area
    b. Misverstand dam to estuary
10. Plantations
11. Terrestrial aliens
    a. Franshoek area near the plantations up to the N1
    b. Wellington to Hermon
12. All WWT plants
13. Pollution areas- cannot be clearly identified as current hotspots are based on historical data (and sampling site lots of point source pollution gets diluted because of tributaries entering the river
14. Stellenbosch municipality -Study done by Brett Keyser to measure discharge from the farmers
15. Agricultural activities (crops) Nitrogen
16. Intensive livestock farming
17. Informal settlements
18. All Towns in close proximity to the river (waste water management)

Session 3: Overview of the Latest Scientific Findings of Potential Climate Change Impacts in the Catchment Areas

Please note, that this appendix has been omitted owing to its size.

Session 4: Reassessing of the Berg Catchment Model Through a Climate Change Lens: Impacts, Needs and Adaptation Options

IMPACTS

- Reduction in stream flow
- Higher variability
- Local effect of wetlands
- Water temperature:
  - E. coli
  - Amplification
  - Biodiversity
  - Diseases
- Hydraulic design criteria
- Flood risk
  - Upper Berg: local
  - Lower berg: regional flood
- Water source/supply ➔ WDM
- Change in rainfall seasonality (later)
  - Evaporation
  - Disease
- Change in crops
  - Exports
  - Foods security
  - Financial inputs and implications
- Reserve/ river health
  - Rule changes (cost/losses)
  - Licensing implications (w/w operations)

NEEDS

- Integrated management plan
- Government must move/react faster on climate change issues
- Financial commitment (funds) from DWA
- Law enforcement (Special environmental law)
- Good data needed to make informed decisions
- Solid and constant communication

ADAPTATION OPTIONS / STRATEGIES

- Carbon credits
  - Agriculture, especially exporters
  - PES (RW Services)
- Water Storage Capacity (increase)
  - Optimising bulk water infrastructure
- Water Demand Management (Integrated)
  - Irrigation ➔ drip
- Climate change as mainstream activity
  - Role of government
  - Resource management -> w/w plant design
  - Lead time dilemma-> public and private sector
  - Green economy
- Legislation
  - Lack of implementation of Tax incentives and Penalties
  - Justice system not backing up/supporting legislation(e.g. Alien invasive vegetation)
- Precautionary principle
- Maladaptation vs. “learning to manage in order to manage to learn”
- Managing for higher uncertainty and variability
- Information management
  - Repetitive data requests by government
  - Funded monitoring/ capacity for operations

V. MAJOR POINTS RAISED BY THE PARTICIPANTS IN THE WORKSHOP DISCUSSIONS

The participants stressed that the transition towards a sustainable and adaptive water resource management system (national and catchment level) must be seen as a higher decision making problem. In particular existing policies need to be revisited and obstacles for a flexible yet sustainable management approach need to be removed. Central government must for example ensure that new mandates relegated to local government (i.e. municipalities and WUAs) must also be combined with the necessary budgets to implement these mandates. Furthermore it was stressed that for the practical implementation of climate change adaptation strategies local decision makers require guidance through appropriate by-laws.

In the workshop the need of an **integrated communication strategy** was accentuated. This communication strategy must link all organizations that are involved in the management of the catchment and must provide for successful vertical as well as horizontal integration. Currently many organizations continue to work in silos with little knowledge of the activities of other organizations. This fragmented approach is one of the greatest obstacles to realized systematic monitoring of current trends and effective implementation of initiatives.

Monitoring systems that provide on a regular basis accurate data about trends and changes in the catchment (e.g. water quality or water quantity) are the backbone of sustainable water resource management. The majority of champions emphasized that without such systems in place they will not be able to make to make informed decisions on current and future changes in the catchment areas. Such monitoring systems do not only need to capture water quality, water consumption and land use changes but must also account for new challenges such as new types of pollutants (e.g. growth hormones and pharmaceuticals.) This in turn requires sufficient funding for the creation and maintenance of adequate monitoring systems as well as close coordination between different organizations involved in the monitoring activities, including a productive science – decision maker interface. The link between scientists and water resource managers is not only crucial for ensuring that all relevant factors are considered in the monitoring process but also that the translation of data into information speaks to the needs of the water managers.

Another factor that was stressed in the workshop is the **science society interface and the role of knowledge creation and communication**. Although the scientific findings presented by Prof. Schulze and Sabine Stuart Hill were highly valued by the participants, they also were concerned how this scientific information could become more relevant for their daily work. There is a general acknowledgement that better and better information (e.g. fine scale information) is required at local decision making level in order to be able to deal with the complexity and uncertainty in the South African water sector. Yet a lot of the existing information, in its current form, cannot be easily used in the day to day decision making. This points to the great need to bridge this gap between science-produced knowledge and decision-making relevant information. Neither the scientists nor the decision makers felt that they are currently in a position to take on such a role.

The discussions on climate change impacts demonstrated that also many use the term climate change, but at the same time there is limited understanding about its causes and projected impacts and how these impacts relate to water availability and water management in South Africa. This shows that decision-makers at all level need to be more sensitized.

VI. REFLECTION AND DISCUSSION ON THE VALUE AND OUTCOMES OF THE WORKSHOP:

The workshop can be seen as a starting point in moving towards a common understanding of the respective catchment, learning collectively about existing vulnerabilities and so called hotspots as well as gaining a better understanding on the projected impacts of climate change in the catchment. More long term engagement is required when it comes to identifying coordinated catchment and decision-maker specific adaptation options. Long term engagement and future learning opportunities are also required for improving engagement and collaboration of the various organizations involved in the water resources management.

The participants were aware that the water resources in their catchment are already under significant stress because of challenges relating to unsustainable development pathways (housing and agriculture), fragmented and uncoordinated water resource management practices and the failure of enforcing existing legislations. However, the true extent of current risks and threats is not known to any of the participants, which is alarming as this lack of knowledge inhibits the identification of priority areas and the proper allocation of resources. With regard to climate change and its impacts on the Berg, the participants are alerted that future climate change projections will most likely affect water availability negatively. Yet, participants found it challenging to make these projections more relevant to their respective spheres of decision making.

VII. THE WAY FORWARD AND NEXT STEPS

The Department of Water Affairs thanks all participants for their valuable inputs. The workshop demonstrated that the impact of climate variation and climate change may have significant impacts on our water resources and it is evident that all water sectors (agriculture, industry and domestic) will affected. There is a need to research alternative methods and to re-look at current Water Conservation and Water Demand Management (WCWDM) strategies to ensure that water resources are manage effective and efficiently as well as conserving what we have.

The greatest concern at this stage is water quality and the impact it has on the agricultural sector which is one of the biggest economical contributors in the Berg Water Management Area (WMA). The Department however, commits itself to improve lines of communication and to work closely with all stakeholders to improve water resource management. Hence, the Department will re-activate the Berg River Reference Group. One of the future initiatives should also be a Water Quality Conference; - as

many of us are doing so much to improve and to protect water quality, yet this is not communicated to other stakeholders and the public. Currently there is a Berg Water Quality Task Team, who is similar to the team who managed the Southern Cape droughts, who is in the process of ensuring that the Berg River's water quality is improving. The Department also takes note that there are already existing platforms on a municipal level and wishes to extend an invitation to all to invite the Department to be part of these platforms. A follow up workshop to this will be held.

Annexure 5: Flip charts of second Mgeni workshop (18th July 2012)

Based on the mapping of sensitive areas from 1st champion workshop prioritise these for interventions:

1. Tributaries
2. Midmar Dam
3. Inanda Dam
4. Darvel
5. Umgeni Vlei
6. Informal Settlements
7. Albert Falls to Nagle Dam

Alternatively, use a "Source to sea approach", i.e. from Umgeni Vlei to Durban.

Identify responsibilities for implementations based on "Needs" lists from 1st champion workshop:

NEEDS identified during 1st champion workshop	Corresponding responsibilities for implementation
Higher resolution of climate change impacts (information and vulnerabilities)	Science and then take / translate to policy level
Translates between science and policy	Authorities themselves
Translates of information/ policies from national to regional and local	DWA, DEA and Departments of Agriculture (national and regional)
Awareness on climate change is needed, policies and laws are in place	"We all have a role to play"
Criteria and indicators limited to laws in order to create obligations/implication and law enforcement	----
Integration across departments and sectors	Provincial and local level (difficult to get industry and NGOs involved)
Institutionalise policies on climate change	----
Education and awareness on climate change (to change people's attitudes)	Is happening especially after COP 17 in Durban, but all need to agree on one message and the time horizon must be relevant to the people. Include schools. Conductor must be DEA.
Relook at 1:50 and 1:100 flood lines	Local authorities

No additional NEEDS identified by champions in the 2nd workshop.

Identify responsibilities for implementations based on "Adaptation Options" lists from 1st champion workshop:

ADAPTATION OPTIONS identified during 1st champion workshop	Corresponding responsibilities for implementation
Sustaining upper catchment area (preserve or conserve upper catchment in its pristine stage)	DAE provincial, DWA regional, KZN Wildlife Stewardship Programme and others
Establish coastal line to deal with sea level rise	Municipalities and DEA national (marine unit)
Relook at flood line specifically 1/100 years	Municipalities and provincial level including KZN Planning Commission
Redesign infrastructure	Municipalities and DWA
Review water quality discharge standards	DWA
Reserve determination	DWA
Assess solid waste management	DEA provincial and Municipalities (hazardous waste at national level)
Review overall storm water management	Municipalities, DWA and provincial Roads Department
Incorporate climate change into land use planning, specifically at local level	Municipalities and provincial level including KZN Planning Commission
Incorporate climate change into policy and ensure implementation	Top down approach, starting at the South African National Climate Change Response Strategy (NCCRS) 2011
Identify priorities ... (buffer, sinks)-precautionary principle, mitigation)	All levels integrated by catchment management authority
Capacitating NGOs and other groups to inform the poor and the vulnerable	Municipalities and DWA and provincial Roads Department
Explore rain water harvesting for all types of houses/settlements (there is a huge problem with this adaptation because people don't trust the source and that an investment in gutters is high	Municipalities and a serious driver at provincial level
Revisit all by-laws (review water quality standards and reserve determination)	DWA (Reserve Determination Directorate) and Municipalities
Sea water desalinisation (bear in mind the costs associated)	Water authorities, DWA and Water Services Providers

Two additional ADAPTATION STRATEGIES identified by champions in the 2nd workshop

(a) Water reuse
(b) Identification and repairing of leaks

Annexure 6: Flip charts of second Berg workshop (17th October 2012)

Based on the mapping of sensitive areas from 1st champion workshop prioritise these for interventions:

1. Upper stretches / catchment first as it feeds the whole system (ownership of land and managing therefor is key); finances and institutions through CMA; develop water safety plan
2. Pollution, especially point pollution by (wine) famers; here ensuring the quality standards of exported fruit are the leverage point
3. New settlements, formal and informal, as well as urbanisation
4. Unlawful water use and water use management

Identify responsibilities for implementations based on "Needs" lists from 1st champion workshop:

NEEDS identified during 1st champion workshop	Corresponding responsibilities for implementation
Integrated management plan	CMA / (DWA)
Government must move/react faster on climate change issues	CMA and DEA
Financial commitment (funds) from DWA	DWA, Municipalities, DEA and many more; DWA needs to coordinate funding from local to national and vice versa
Law enforcement (Special environmental law)	DWA Western Cape, Municipalities and Agriculture
Good data needed to make informed decisions	Stakeholders and CMA as custodians of data in the sense of access and quality control
Solid and constant communication	DWA and others

No additional NEEDS identified by champions in the 2nd workshop.

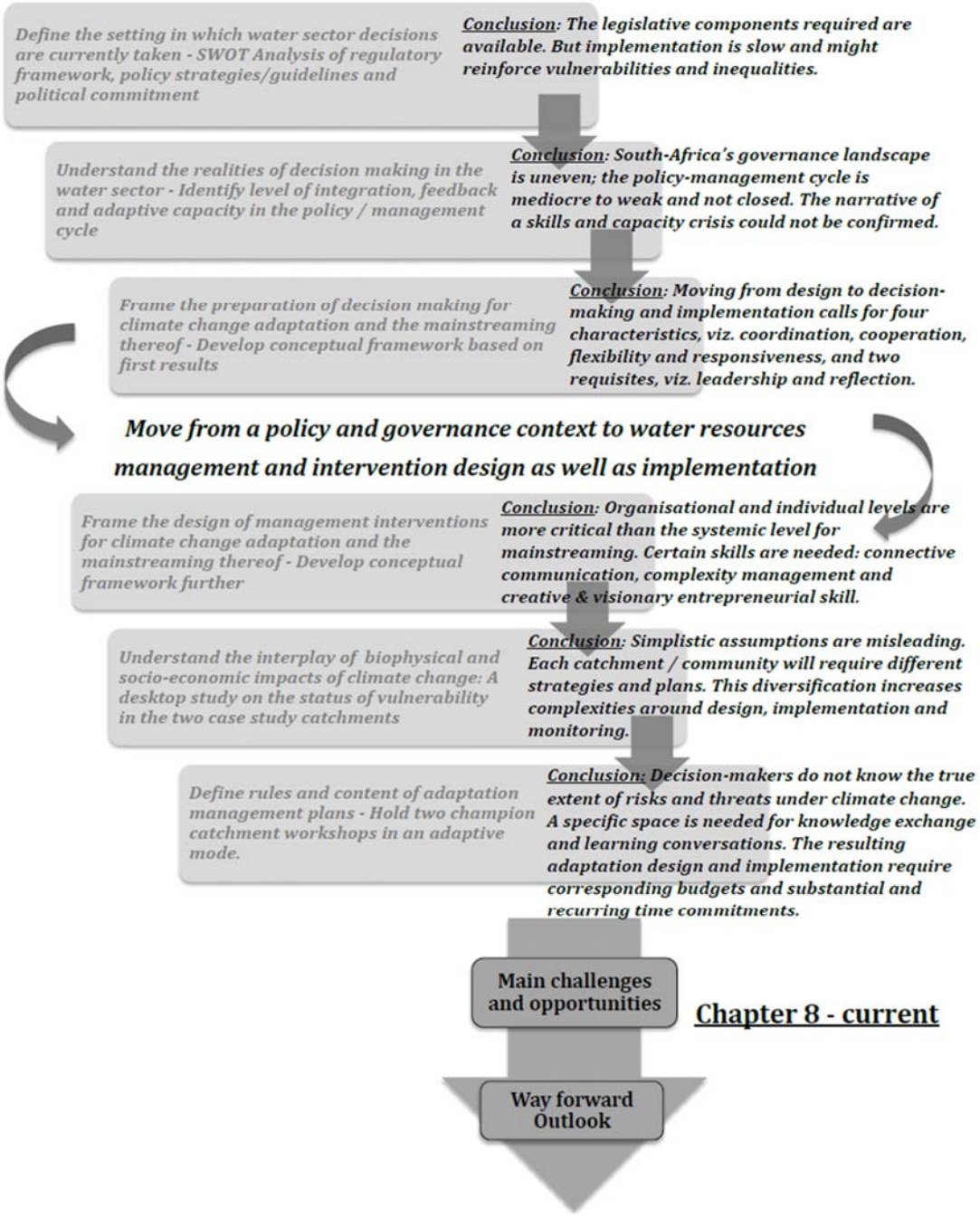
Identify responsibilities for implementations based on "Adaptation Options" lists from 1st champion workshop:

ADAPTATION OPTIONS identified during 1st champion workshop	Corresponding responsibilities for implementation
Carbon credits - Agriculture, especially exporters - PES (RW Services)	Private land owners
Water Storage Capacity (increase) - Optimising bulk water infrastructure	Unrealistic! Think out the box, not infrastructure but soil, aliens etc. E.g. tax incentives (Treasury)
Water Demand Management (Integrated) - Convert irrigation to drip	Municipalities, framers, DWA, Department of Agriculture
Climate change as mainstream activity	Government is the custodian

- Role of government - Resource management -> w/w plant design - Lead time dilemma-> public and private sector - Green economy	
Legislation - Lack of implementation of Tax incentives and Penalties - Justice system not backing up/supporting legislation(e.g. Alien invasive vegetation)	National AND local government
Precautionary principle	Science, WRC, all part-takers in the water-system
Maladaptation vs. "learning to manage in order to manage to learn"	Science, WRC, all part-takers in the water-system
Managing for higher uncertainty and variability	Science, WRC, all part-takers in the water-system
Information management - Repetitive data requests by government - Funded monitoring/ capacity for operations	Science, WRC, all part-takers in the water-system

Key is river basin management through an appropriate CMS for which the municipalities and the CMA are responsible.

8. FINAL DISCUSSION AND CONCLUSIONS



Water may be considered the catalyst of our social-wellbeing, of economic growth and of environmental resilience across the globe. Thus, the impacts of climate change – especially when adding onto existing vulnerabilities and lack of good governance – exacerbate and may even amplify the shortfalls of governance and water management.

This is specifically true for developing countries such as South Africa, that already struggle with the implementation of innovative and complex legislation as well as having to deal with water scarcity and aging and often dysfunctional infrastructure. However, a variety of opportunities, seen as pockets of innovation, exist that may be the nuclei for learning and resultant improvement of governance and water management.

The thinking or paradigm that the research has been founded on has been from a point of scientific informed decision-making. However, the decision-making itself, because it happens often by an individual at a specific time and being part of a specific organisation, needs to shift his or her thinking and intervention design towards contesting, discussing and negotiating knowledge production and solution design in order to 'fit' the dynamics of ecology, society and economy at a specific point in time for a specific place. At the same time the individual or a group of individuals require the spanning of scales and organisational boundaries in order to ensure the sustainability of the adaptation interventions. This implies avoiding maladaptation, including the transfer of vulnerabilities, the amplification thereof and other negative impacts that may even be located beyond the water sector.

Thus, the conceptual as well as case study research of this thesis has shown that the overall governance system of a country sets the scene in order for the individual decision-maker and manager to act. Boundaries are set by legislation and now also by climate change policies, which at the same time may create an urgency and, hence, a motivation to undertake climate change adaptation. This urgency and motivation is, however, biased and manipulated and potentially even eroded by current vulnerabilities, a lack of specific skills and organisational inflexibility. As shown in Chapters 2 to 7, a strategic approach for mainstreaming adaptation into day-to-day decision-making will require climate change policies to simultaneously clarify implementation tools and pathways, will have to take current stresses and vulnerabilities not only into consideration, but learn to understand their complexities and interlinkages, and use them as a points of departure for adaptation design and implementation. Lastly, the dynamics of change in our catchments are high, as is the research arena of climate change itself. Hence, knowledge management and negotiating rules will be fundamental to the respective decision-making and implementation of management interventions in a future of climate change.

In regard to the hypotheses (underlined) established in Chapter 1 the following results have been derived:

(a) ‘A pro-active management style needs to evaluate and adapt its ways of decision-taking on a relevant time scale for the water user’: South Africa’s water managers on all levels are able to identify what are currently burning issues, but can only partially estimate the impacts of climate change. The uneven implementation and knowledge landscape keeps them ‘hostage’ to a re-active management style. A relevant time scale for the design of interventions and their evaluation seems to be annual activities tailored to certain catchment needs. But taking the uneven landscape of management into consideration and combining this with the highly dynamic research landscape surrounding climate change and adaptation, it becomes questionable if this is a doable approach.

(b) ‘Only through participatory processes is an understanding of the present, and issues around uncertainties, possible. Furthermore, barriers and drivers of change can be identified and incorporated into the framework, making it real and implementable’: This has been proven true in all aspects of the research undertaken. Management and intervention design is strongly linked to the systemic, organisational and individual realities of a country and its society. Even more so is their success linked to the communication and cooperation abilities of individuals and their respective home organisations.

(c) ‘Incorporating Spaces for Dialogue will induce system innovations for Integrative and Adaptive Water Management’: The champion workshops have shown that new and seemingly robust knowledge can only be gained in a cooperative learning environment if maladaptation is to be avoided, e.g. by simplified assumptions in regard to climate change impacts, their resulting vulnerabilities and intervention design. Furthermore, they offer a safe space where new skills can be trained, with these including connective communication, complexity management, creative and visionary entrepreneurial skills.

8.1 Main Challenges and Opportunities

The *framework* designed around understanding and preparing climate change adaptation activities and interventions shows high levels of complexity for water management as well as a diversity of challenges towards the overall water governance system. A large number of players need to be involved, and processes of understanding vulnerabilities and designing, as well as prioritising, adaptation interventions will take up substantial

time and financial support. Furthermore, the actual *mainstreaming* of climate change adaptation will place heavy demands on decision-makers (including having to learn new skills) when discussing the prioritisation of management interventions and, finally, evaluating and deciding about trade-offs that need to be made. As a result, the preparing as well as the decision-making itself around management interventions for adaptation will be challenging and will include difficult decisions having to be made. It also calls for multi-level responses where management responses may differ from the national down to a local scale, as well as from within to outside the water sector.

One of the main *challenges* will thus be to build new partnerships, potentially new organisational arrangements and a strong focus on gathering a variety of socio-economic information that is included in robust and continuous monitoring processes. Nonetheless, the case of South Africa has shown that even in a challenging landscape of uneven implementation and knowledge, windows of opportunity for policy as well as for management exist to start implementing certain aspects of the suggested process. The research on the Policy-Management Cycle has shown that not only are technical skills are in short supply in South Africa, but that management skills are often inflexible and appropriate leadership is absent. Therefore, the other major challenge of acquiring the new skills which were identified might be a window of opportunity to overcome the skills gap and to close the Policy-Management Cycle at the same time. These lie beyond the conventional academic ambit and what is currently required of good governance. A paradigm shift will be needed on many levels and with multiple dimensions to support this process. Leadership and learning, as traditionally defined, will no longer suffice.

Although the multilevel response for designing and prioritising adaptation interventions should have foci on all management levels, i.e. international, national, regional and local, the issues around understanding impacts of hydrological responses and resulting vulnerabilities show a higher urgency and relevance towards the regional and local level. This is where closing the information gap on the interplay with the socio-economic system under future climate change will be critical, as this is the space where sense can be made in an integrated manner and where monitoring of interventions, trade-offs and thus identifying successes as well as maladaptation, is feasible. Therefore, this is the scale on which on-going sense making and re-design of management interventions will lead to adaptive management that is relevant to the individual as well as the system. National and global levels are less relevant than regional and local ones; however, they offer an important space for guidance and

integration between catchments. This might offer a space for comparing trade-offs of certain adaptation activities.

The case of South Africa has shown how heavily a system can depend on centralised tools and decision-making, although it offers everything for an integrative and adaptive management approach on a regional and local scale. Management can end up being 'hostage' to a variety of other systemic, organisational and political issues. Thus, South Africa faces a huge challenge in regard to urgently needed innovations in governance in order to create the relevant knowledge, to learn and negotiate adaptation interventions to climate change, and to continually assess its performance in that regard.

8.2 Verifying the Framework which was Developed

All workshops have confirmed the conceptual framework needed for governance and management to successfully mainstream adaptation to climate change within South Africa's water sector. The following aspects were found to be central in this regard:

(a) The identification of positive interplay between levels, scales and sectors combined with the request for leadership from national level and guidance through by-laws on local level confirm the characteristics of *coordination* and *responsiveness*.
(b) *Flexibility* can be detected in all management issues discussed, including the requests for tailored and regular monitoring.
(c) The overarching issues of governance require an innovative approach and definition of *cooperation* within and beyond the water sector. The science-policy and science-society interface have been re-occurring themes, acknowledged by the champions as being imperative to sound decision-making.

Furthermore, the term 'adaptive capacity', as defined in the glossary of terms, is considered to be far too narrow and simplistic. It suggests that there could be drastic limits to adaptation itself when the potential of a system is low. But, as the research of this thesis has clearly shown, the available abilities to mainstream adaptation may be a promising substitute when lack of adaptive capacity is a constituent of the system under investigation, e.g. the water sector. The ability to mainstream is of a nature that may be grown by any individual, organisation or system, *viz.* by certain individual skills to be honed, by an organisational culture of mainstreaming to be encouraged and by an enabling legal and policy framework to be in place. Furthermore, it is not the entire governmental system nor the water sector that is relevant, but rather key elements that

may lead along and give guidance with regard to issues of change, mainstreaming adaptation and acquiring specific skills.

8.3 Looking Forward

The water sector of South Africa offers a diversity of windows of opportunity to understand, design and implement adaptations to climate change. While mainstreaming of adaptation to climate change has reached an acceptable level in South Africa in regard to the systemic level, it is the organisational and individual understanding of the relevant climate change issues (impacts, vulnerabilities) that are limited and could very well end up being a springboard for maladapation. However, windows of opportunity exist in regard to the climate change discourse itself, to political activities and to priorities as well as the legislative and, hence, regulatory format (including 5-year review cycles of, for example, the National Water Resource Strategy and policy re-alignment processes). The engagement with such windows would need further investigation and research. However, the existing 'regulatory window of opportunity' may be a good leverage point, as it is easily identified and is considered reliable in in its availability.

Overall, the research has shown that South Africa displays an inconsistent governance and management system. As alluded to before, a major challenge is the uneven landscape in regard to many of the issues discussed, *viz.* integrative and holistic thinking, law enforcement, capacity issues of different types and ineffective communication with stakeholders. Mainstreaming climate change into water related decision-making hardly seems possible in such a *modus operandi* and it must be assumed that this would place a stronger emphasis on the legislative background of the country. But low levels of implementation and a variety of capacity issues, which were perceived as 'just' bottlenecks in the course of the research, actually seem to become disconnects between levels and scales of water governance and management. The notion of disconnects will need further investigations as well.

Two themes of research have been re-occurring in different contexts and, hence, would also need further investigation in the context of adaptation to climate change in the water sector. These are cooperation (as alluded to above) and knowledge brokering between science and management as well as between science and society. Knowledge brokers or boundary organisations that are capable of bridging the boundaries which have been erected between sectors or communities of knowledge could well be leverage

points for more complex levels of mainstreaming. In the context of the developing world where the most pressing issues exist in regard to impacts of climate change and current levels of vulnerability are high already, such brokering or boundary work would need to be discussed and investigated for a lesser skilled environment as well as for more fragile organisational structures.

Finally, all inquiries into the different aspects of water management, impacts of climate change and intervention design as well as mainstreaming of all of the above in the water sector, need to be differentiated and understood in more detail. Simplifying and making assumptions based on what is known thus far is a dangerous undertaking in a world of global change and highly dynamic societies. The knowledge management and communicative skills of the past will not suffice in designing appropriate solutions for the future. In order to be effective and sustainable in our development, we need to take the risk of planning into the unknown and to step out of what and how we have done management so far. People are more robust and have more endurance than we as researchers and also politicians think. As long as there is hope for something better or more successful ahead, there will always be those few who believe and motivate the majority to follow on the path of hard work, learning and innovation.

8.4 Dimensions of Innovation and New Knowledge from this Research

The research carried out and the results presented reflect two main dimensions of innovation, *viz*. mainstreaming climate change as a multi-level and multi-scale process and understanding the decision-making environment of the water sector for adaptation design. Furthermore, the process orientated and transdisciplinary approach that is informed by case studies as well as theory shows great potential in delivering a framework within which climate change adaptation planning, intervention design, implementation and monitoring can be considered for decision-making. Additionally, the framework offers the flexibility to tailor all activities to a particular space or level, e.g. the catchment, an administrative unit or a sector specific issue. Such a dynamic system that includes individual capacities automatically creates space for innovations in governance and management, and actually represents an innovation in governance itself.

Other results gained in this research that contribute to new knowledge can be summed up as followed:

(a) Mainstreaming climate change into day-to-day decision-making is a relatively new research domain. In the South African water context this theme had not been researched in depth to date and the present thesis is a starting point into this diverse field of knowledge that will be crucial for understanding and applying the concept of mainstreaming.
(b) The process and action research orientation of this thesis has allowed for dealing with 'real world problems' and designing a relevant and applicable framework for preparing decision-making.
(c) An understanding was gained that the scale of inquiry needs to be relevant in regard to context, *viz*. for the South African case water-policy mainly at the national scale, water-management mainly at the catchment scale, decision-making and implementation mainly at the individual scale, and that all inquiries have to be combined for pertinent results and robust adaptation planning and implementation.
(d) Recognising the interplay of the legal canvas and the realities of decision-makers has contributed significantly to the theory of mainstreaming as well as adaptation design through the case studies.
(e) Dealing with highly complex and dynamic systems such as catchments, socio-economic systems and climate change calls for a rigorous investigation into the interaction of the systems elements, e.g. biophysical features, organisational characteristics and individual skills. Making assumptions without taking scientific input, joint sense making and cooperative intervention design into account is a dangerous undertaking that probably will lead to maladaptation and increases in vulnerabilities.
(f) The learning and managerial skill environment has been identified as central for adaptation design, decision-making and implementation as well as for mainstreaming. Thus, the setting of the individual within the wider governance context, but specifically within his/her organisation and the policy landscape needs to be the focus when robust and sustainable solutions are to be found in a future of climate change.

Overall, the research has demonstrated clearly how fundamental the understanding of the water policy and governance context is, but that moving into the water management dimension with actual intervention design and implementation calls for the constant interplay and reflection of systemic, organisational and individual issues. Furthermore, leadership and social learning will not suffice, but have to be complemented with certain skills which create the connection between organisations and individuals, and

which facilitate the manoeuvring through the complexities of decision-making while being guided by creative and visionary notions.

Given the uncertainties of all global change dimensions and their highly dynamic nature, especially in developing countries such as South Africa, the need for moving away from ‘business as usual’ is uncontested. However, an enabling legal and policy governance landscape can only be considered a starting point. The actual management and decision-making environment is far more crucial, and the individual water manager becomes a key player here. New ways will have to be found in capacitating these water-managers with certain skills as alluded to above, with the freedom to communicate and cooperate, as well as being granted trust and financial means to develop adaptation options in an encouraging environment for decision-making and implementation.